March 1999

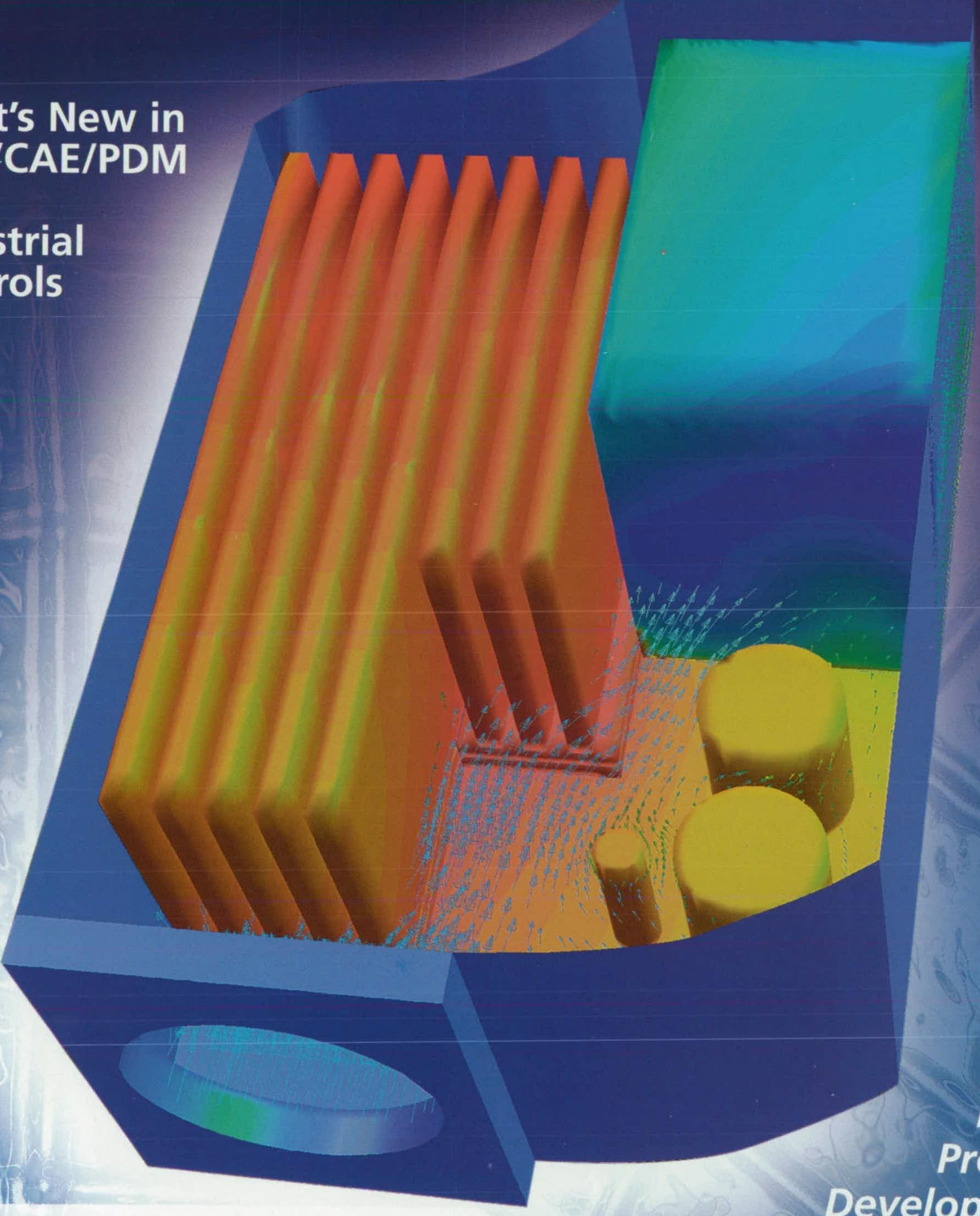
Vol. 23 No. 3

TECH BRIEFS

ENGINEERING SOLUTIONS FOR DESIGN & MANUFACTURING

What's New in CAD/CAE/PDM

Industrial Controls



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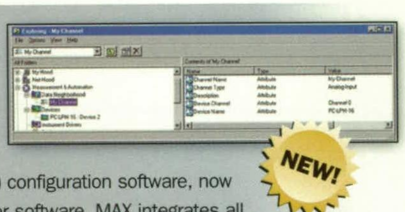

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Increase your DAQ board signal range with the SCXI-1104, our new 32-channel ±42 V multiplexer. Expand DMM channel count with the SCXI-1127 high-voltage relay multiplexer. Or, configure the SCXI-1127 into matrix mode for flexible signal routing. SCXI is your signal connection for PC-based DAQ!

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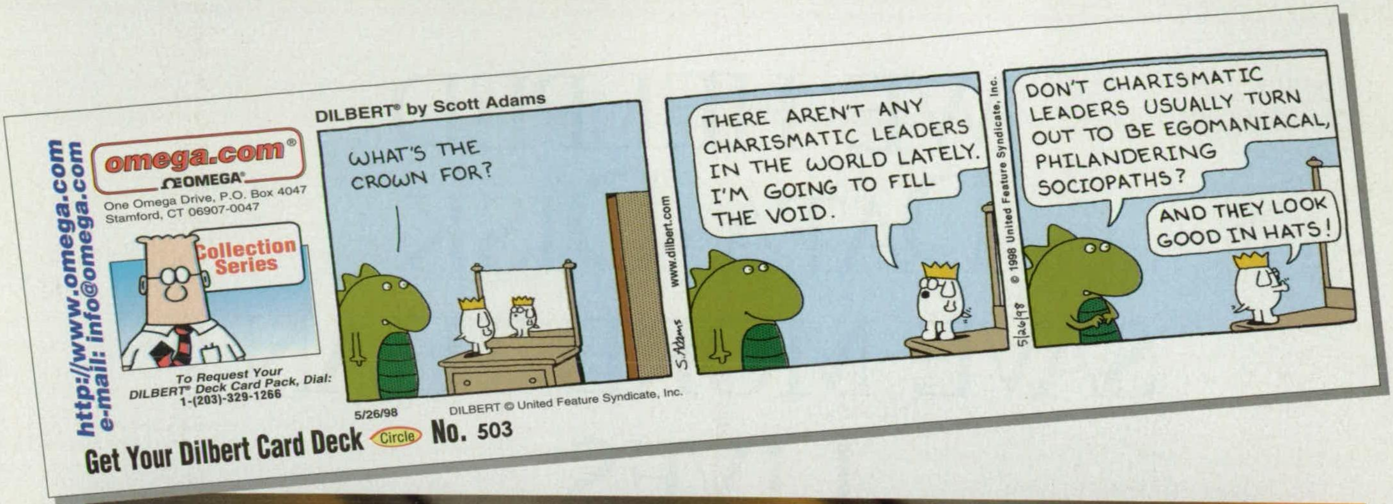
For More Information Circle No. 573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COMPAQ

March 1999 • Vol. 23 No. 3

NASA TECH BRIEFS

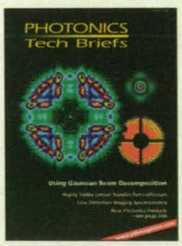
ENGINEERING SOLUTIONS FOR DESIGN & MANUFACTURING

FEATURES

BRIEFS

DEPARTMENTS

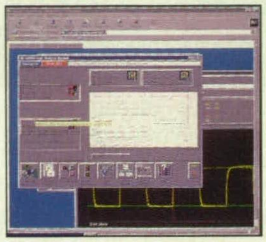
SPECIAL SUPPLEMENTS



Contents *continued*

PRODUCT OF THE MONTH

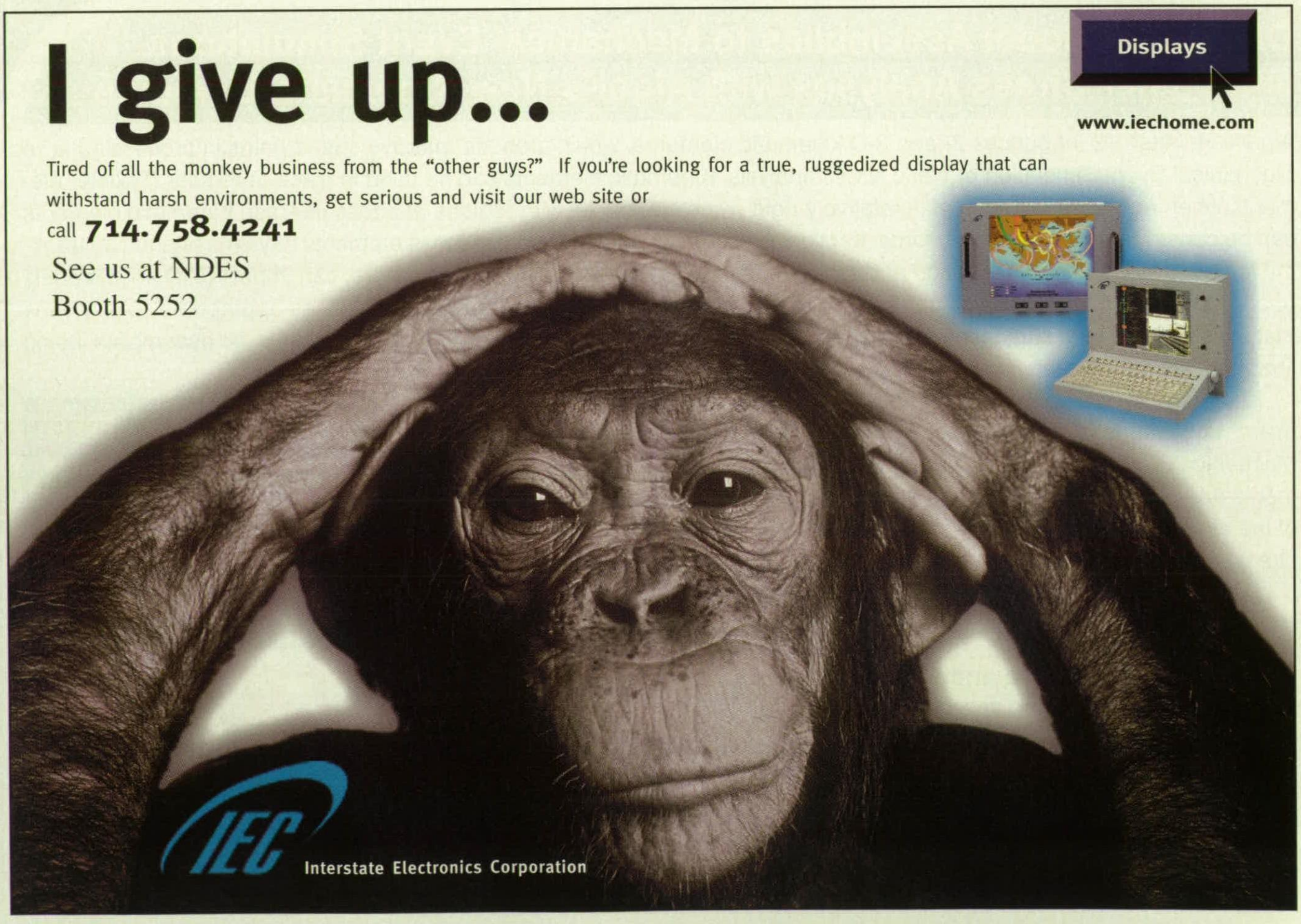
Hewlett-Packard offers the first Web-enabled logic analyzer.



ON THE COVER

This system-wide thermal analysis of a power unit was created with Icepak™ thermal analysis and design software for electronics cooling from Fluent, Inc., Lebanon, NH. The software supports a direct interface with Parametric Technology Corp.'s Pro/ENGINEER mechanical design software. For more information on Icepak, and other CAD/CAE/PDM software innovations, see the Special Coverage beginning on page 30.

(Image courtesy of Fluent, Inc.)



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BPA INTERNATIONAL

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Combinations of high speed, high temperature and/or high pressure, cause conventional rubber-lip seals to wear out prematurely or fail suddenly. While a single requirement such as low friction may restrict the use of rubber lip seals, applications that combine several extreme operating conditions virtually eliminate the successful use of elastomeric seals.

Turcon® Varilip® rotary shaft seals, made from high-performance polymers, offer an alternative to rubber lip seals for these difficult applications. In addition, higher performance and increased efficiency are now possible due to the Turcon® Varilip®.

The Turcon® Varilip® offers universal chemical compatibility, exhibits very low friction, operates above 12,000 sfpm and produces leak-tight sealing. These seals are available in standard inch nominal and metric sizes in addition to a vast range of custom sizes and configurations.

For an extra measure of performance and reliability in difficult operating conditions, without the problems of degradation, embrittlement and premature wear, the Turcon® Varilip® is a very effective alternative to rubber lip seals.

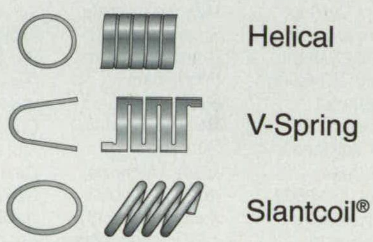
Busak+Shamban, 800-767-3257.

For More Information Circle No. 531

Three spring-energizer designs make the Turcon® Variseal™ more versatile.

With a choice of three spring-energizer designs, engineers can now specify seals optimized for virtually any application.

Inserted in a Turcon® engineered-polymer jacket, these springs permanently energize the Variseal™ to maintain a positive seal over a long operating life. Each of the three designs—the Helical, "V" and Slantcoil® Springs—offer decisive advantages for a variety of applications.



Choosing the right spring is a critical step in the design process. The Helical Spring applies the highest unit load, making it an excellent choice for static and slow-speed reciprocating applications. For high-speed reciprocating, or moderately fast rotary applications, the V-Spring is a better choice. This spring is also used for applications with abrasive environments where superior scraping is critical.

The Slantcoil® Spring, which is designed for both rotary and reciprocating service, is unique in that its spring force is virtually constant over a wide deflection range. Because it compensates for tolerances in the gland and for wear, it helps to ensure an exceptionally long operating life.

All three spring designs are available in a wide variety of sizes, spring loads and metal alloys to match the needs of each applications precisely.

Busak+Shamban, 800-767-3257.

For More Information Circle No. 532

NASA Commercial Technology Team

NASA's R&D efforts produce a robust supply of promising technologies with applications in many industries. A key mechanism in identifying commercial applications for this technology is NASA's national network of commercial technology organizations. The network includes ten NASA field centers, six Regional Technology Transfer Centers (RTTCs), the National Technology Transfer Center (NTTC), business support organizations, and a full tie-in with the Federal Laboratory Consortium (FLC) for Technology Transfer. Call (206) 683-1005 for the FLC coordinator in your area.

NASA's Technology Sources

If you need further information about new technologies presented in *NASA Tech Briefs*, request the Technical Support Package (TSP) indicated at the end of the brief. If a TSP is not available, the Commercial Technology Office at the NASA field center that sponsored the research can provide you with additional information and, if applicable, refer you to the innovator(s). These centers are the source of all NASA-developed technology.

Ames Research Center
Selected technological strengths: Fluid Dynamics; Life Sciences; Earth and Atmospheric Sciences; Information, Communications, and Intelligent Systems; Human Factors.
Carolina Blake
(650) 604-0893
cblake@mail.arc.nasa.gov

Dryden Flight Research Center
Selected technological strengths: Aerodynamics; Aeronautics Flight Testing; Aeropropulsion; Flight Systems; Thermal Testing; Integrated Systems Test and Validation.
Lee Duke
(805) 258-3802
lee.duke@dfrc.nasa.gov

Goddard Space Flight Center
Selected technological strengths: Earth and Planetary Science Missions; LIDAR; Cryogenic Systems; Tracking; Telemetry; Command.
George Alcorn
(301) 286-5810
galcorn@gsfc.nasa.gov

Jet Propulsion Laboratory
Selected technological strengths: Near/Deep-Space Mission Engineering; Microspacecraft; Space Communications; Information Systems; Remote Sensing; Robotics.
Merle McKenzie
(818) 354-2577
merle.mckenzie@ccmail.jpl.nasa.gov

Johnson Space Center
Selected technological strengths: Artificial Intelligence and Human Computer Interface; Life Sciences; Human Space Flight Operations; Avionics; Sensors; Communications.
Hank Davis
(281) 483-0474
hdavis@gp101.jsc.nasa.gov

Kennedy Space Center
Selected technological strengths: Environmental Monitoring; Sensors; Corrosion Protection; Bio-Sciences; Process Modeling; Work Planning/Control; Meteorology.
Gale Allen
(407) 867-6626
galeallen-1@ksc.nasa.gov

Langley Research Center
Selected technological strengths: Aerodynamics; Flight Systems; Materials; Structures; Sensors; Measurements; Information Sciences.
Dr. Joseph S. Heyman
(804) 864-6006
j.s.heyman@larc.nasa.gov

Lewis Research Center
Selected technological strengths: Aeropropulsion; Communications; Energy Technology; High Temperature Materials Research.
Larry Viterna
(216) 433-3484
cto@lerc.nasa.gov

Marshall Space Flight Center
Selected technological strengths: Materials; Manufacturing; Nondestructive Evaluation; Biotechnology; Space Propulsion; Controls and Dynamics; Structures; Microgravity Processing.
Sally Little
(256) 544-4266
sally.little@msfc.nasa.gov

Stennis Space Center
Selected technological strengths: Propulsion Systems; Test/Monitoring; Remote Sensing; Nonintrusive Instrumentation.
Kirk Sharp
(228) 688-1929
ksharp@ssc.nasa.gov

NASA-Sponsored Commercial Technology Organizations

These organizations were established to provide rapid access to NASA and other federal R&D and foster collaboration between public and private sector organizations. They also can direct you to the appropriate point of contact within the Federal Laboratory Consortium. To reach the Regional Technology Transfer Center nearest you, call (800) 472-6785.

Joseph Allen
National Technology Transfer Center
(800) 678-6882

Ken Dozier
Far-West Technology Transfer Center
University of Southern California
(213) 743-2353

Dr. William Gasko
Center for Technology Commercialization
Massachusetts Technology Park
(508) 870-0042

J. Ronald Thornton
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(216) 734-0094

NASA ON-LINE: Go to NASA's Commercial Technology Network (CTN) on the World Wide Web at **http://nctn.hq.nasa.gov** to search NASA technology resources, find commercialization opportunities, and learn about NASA's national network of programs, organizations, and services dedicated to technology transfer and commercialization.

NASA Program Offices

At NASA Headquarters there are seven major program offices that develop and oversee technology projects of potential interest to industry. The street address for these strategic business units is: NASA Headquarters, 300 E St. SW, Washington, DC 20546.

Carl Ray
Small Business Innovation Research Program (SBIR) & Small Business Technology Transfer Program (STTR)
(202) 358-4652
cray@mail.hq.nasa.gov

Dr. Robert Norwood
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rnorwood@mail.hq.nasa.gov

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rcrouch@hq.nasa.gov

Granville Paules
Office of Mission to Planet Earth (Code Y)
(202) 358-0706
gpaules@mtpe.hq.nasa.gov

NASA's Business Facilitators

NASA has established several organizations whose objectives are to establish joint sponsored research agreements and incubate small start-up companies with significant business promise.

Wayne P. Zeman
Lewis Incubator for Technology
Cleveland, OH
(216) 586-3888

Dan Morrison
Mississippi Enterprise for Technology
Stennis Space Center, MS
(800) 746-4699

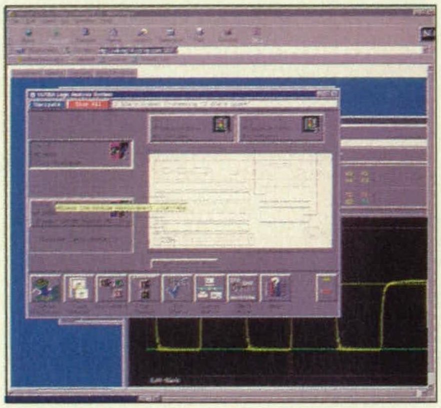
Joe Boeddeker
Ames Technology Commercialization Center
San Jose, CA
(408) 557-6700

Marty Kaszubowski
Hampton Roads Technology Incubator (Langley Research Center)
Hampton, VA
(757) 865-2140

If you are interested in information, applications, and services relating to satellite and aerial data for Earth resources, contact: Dr. Stan Morain, **Earth Analysis Center,** (505) 277-3622.

UpFront

PRODUCT OF THE MONTH



Hewlett-Packard, Palo Alto, CA, has introduced the first Web-enabled, remote-control logic analyzer. The HP 16600A and 16700A logic analysis systems now feature Web-server capability, allowing users to access an HP logic analyzer from anywhere — over the Internet or through an intranet — using Version 4.0 or higher of Microsoft® Internet Explorer or Netscape Communicator browsers. Web-enabled control allows users to check the status of a logic analysis session without being anywhere near the analyzer. PC users can move data from a logic analyzer onto a Microsoft Excel spreadsheet for post-processing by clicking a toolbar in HP BenchLink XL software from within the Excel program. Logic analyzers can be programmed with custom applications and test suites using Visual Basic or Visual C++ programs.

For More Information Circle No. 744

NASA Camera Helps Restore Flag

NASA scientists who developed a near-infrared camera to explore Mars and Jupiter plan to commercialize the device. The group has several agreements in place, including one with the Smithsonian Institution. John Hillman used the Acousto-Optic Imaging Spectrometer (AImS) to photograph the Star-Spangled Banner and collect data for the Institution's three-year project to preserve the historic flag.

Normal infrared cameras could not be used because all parts of the wool flag reflect the same amount of heat. The near-infrared camera, however, can detect stains and deteriorated areas not visible to the human eye by comparing the reflected light from different areas. The 30 x 34" flag flew over Fort McHenry in Baltimore during the War of 1812, and was the inspiration for Francis Scott Key's "Star-Spangled Banner."

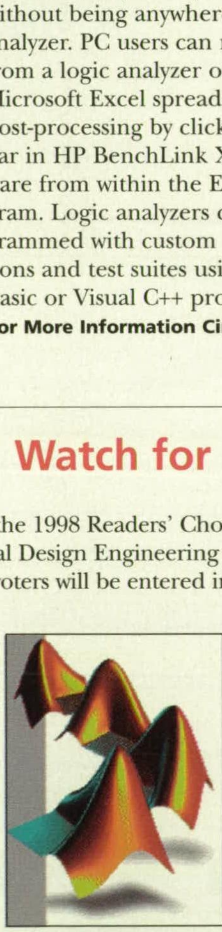
Another application for the camera is to determine the pigment used in paintings, which can distinguish an authentic piece from a forgery. The National Gallery of Art is looking into developing a project with Hillman to examine its paintings. Other applications include skin cancer research, cancer surgery, and analyzing prehistoric sites.

For more information, contact NASA's Goddard Space Flight Center at 301-286-3630.

Watch for the Winners!

Thanks to all of you who voted for the 1998 Readers' Choice Product of the Year Awards. The awards will be presented at a reception held during the National Design Engineering Show in Chicago on the 15th of this month, and we'll announce them here in next month's issue. All voters will be entered in a random drawing to win free software packages, including:

- MATLAB 5.3 technical computing software from The MathWorks of Natick, MA. MATLAB integrates computation, visualization, and programming into a flexible environment. Some of the new enhancements in this version include a new Plot Editor, support for reading and writing Portable Network Graphics (PNG) images, and a suite of visualization functions for volumetric data, including isosurfaces and streamlines. *(Visit The MathWorks at www.mathworks.com for more information on MATLAB.)*



MATLAB

- CADKEY 98 2D/3D CAD software from Baystate Technologies, Marlborough, MA. The Windows program features FastSOLID™ and ACIS® 4.2 solid modeling technology. New enhancements include multiple document interface, a CADKEY 3D viewer, and Photorealistic Rendering for creating life-like images of 3D models created in CADKEY. A new STEP™ translator enables import and export of CAD data. *(Visit Baystate at www.cadkey.com for more information on CADKEY.)*

Thanks to both Baystate Technologies and The MathWorks for providing these valuable prizes.

Reader Forum

Reader Forum is devoted to the thoughts, concerns, questions, and comments of our readers. If you have a comment, a question regarding a specific technical problem, or an answer to a question that appeared in a recent issue, send your letter to the address below.

From our Online Reader Forum:

I'm interested in using silicon nitride honeycomb structures for high-temperature applications. I'd like to find a source of, or details on how to make, Si_3N_4 honeycomb or any other ceramic honeycomb structures. I need it to be 1.5 to 2" thick and 10" square. I'd appreciate any information on companies that offer this type of product.

Bob Pekowski
Rpekowski@hotmail.com

I am looking for information on contaminants found in purge gas systems for clean applications attributed to materials used to plumb the system. I'd also like to find recommended systems for various applications. Thank you.

Louise Walker
Louise.a.walker@lmco.com

Your web site (www.nasatech.com) is a wonderful site to visit. Thank you for your efforts in sharing NASA technology with the public. NASA lifts our eyes toward the challenges that await us in the next century, and it is our great fortune that time and chance have made it possible for these great achievements into the new millennium. Recent space flights may well define our course and our character for decades to come, both in private life and in industry.

John Ziska
Ridge Tool Co.
Elyria, OH
Jziska@ridgid.com

Your July 1998 issue featured the Superprox® proximity sensor from Hyde Park Electronics (UpFront, p. 16). It turns out that this device may have application potential in solving one of our sensing problems. Thank you.

Ben Nies
United Defense L.P.
Minneapolis, MN
612-572-7260

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Please include your name, company (if applicable), address, and phone number or e-mail address.

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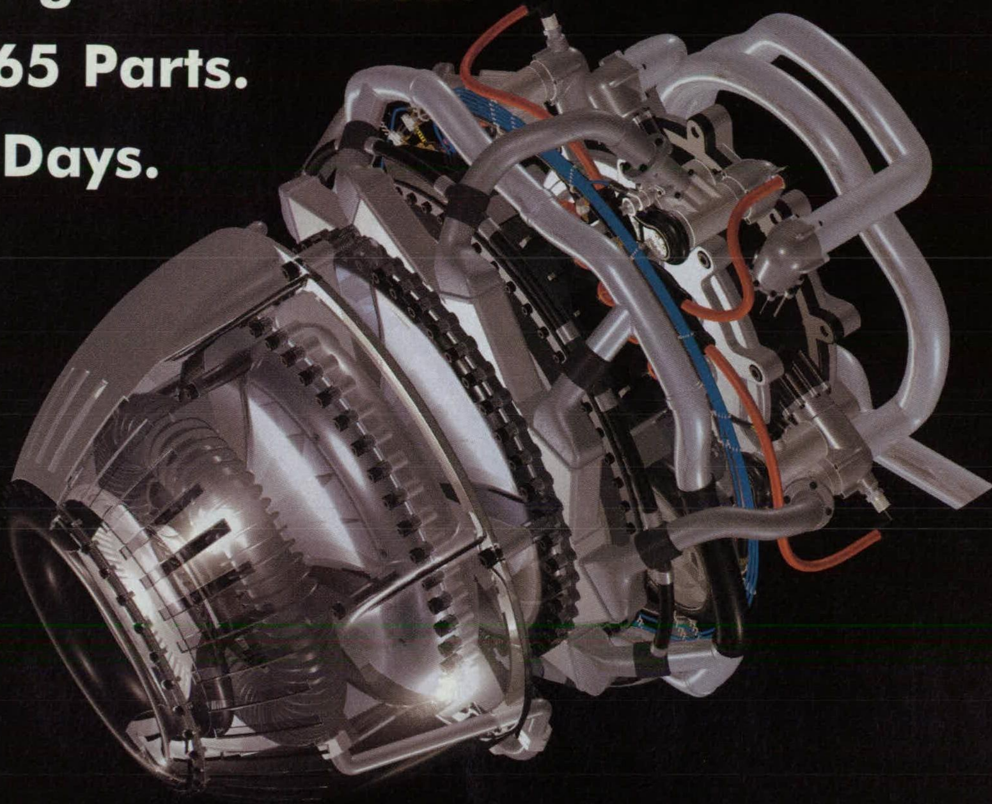
20 Days.



Revolutionary

For a long time industrial designer Simon Floyd had an idea for a new type of engi
He also had at his fingertips one of the leading "high end" CAD systems, but the one thi
he didn't have was spare time. "This is a complex assembly and the task of designing it
any conventional CAD system was just too daunting. However, once I got my hands
IronCAD, I finally had the power to realize my vision," says Mr. Floyd. IronCAD's uniq
Drag & Drop Solid Modeling and Design Flow™ Architecture gave him the power to not o
work fast, but to innovate while he designed. He's become so enthusiastic about IronCA
he now offers it to his clients. To see a case study of Simon Floyd's awesome engine desi
and to learn more about how IronCAD is powering the next industrial revolution, log on

www.**ironcad**.com

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IRON CAD
VISIONARY DESIGN SYSTEMS

Join the revolution or be left behind.

"I don't know how you would start a company like ours today if you were doing it from scratch," said Dr. Daniel Wilde, president of NERAC, Tolland, CT. Fortunately, his company had NASA's help when it was established in 1966 as one of the agency's Regional Dissemination Centers (RDCs). NERAC went on to become one of NASA's most successful spinoff ventures. Today, NERAC provides information and reference services to thousands of companies.

"NASA's Space Act says that NASA has a responsibility for disseminating the results of its technology for the maximum public good," Wilde explained. "In the 1960s, NASA's Administrator came up with the idea to put NASA and universities together to help disseminate NASA technology. By working together, the university would act as the interface with business and translate business needs to NASA, and vice versa. These were called Regional Dissemination Centers. There was one in each major region of the U.S., starting with us in Connecticut, and including North Carolina, Florida, Pittsburgh, Indiana, and California."

NERAC's contract with NASA was through the University of Connecticut, but as Wilde explained, it wasn't the standard grant program. "Our particular situation was a contract, and we had obligations we had to fulfill in order to keep NASA funding. Having a contract and having requirements, we had to learn how to budget, how to make reports, and how to tell NASA what we thought we had to change to do better. So, we learned how to analyze our own performance. They gave us 19 years of interfacing with customers. And we found out a lot of things about the business that didn't work."

Eventually, NERAC outgrew NASA. "The university got larger and larger, and by 1985 we were by far the largest of the NASA RDCs. The university suggested that our center should be independent. So that's what we did," said Wilde.

The Business of Information

From its beginnings with NASA, to its current status, NERAC has remained an "information company." Its customers are corporations trying to keep up with rapidly changing technologies, products, and business strategies. Company libraries and reference departments don't always have the staff or technical resources to locate and document the information necessary to do their business effectively. That's where NERAC has built its niche.

"We feel we're an adjunct to the corporate information center, not a replacement," said Wilde. NERAC employs a staff of skilled technologists, engineers, and scientists experienced in a variety of technical industries. But it wasn't always that way, according to Wilde. "In the early days, NASA's concept was that we would use college professors to answer the customers' questions. The problem with college professors is that they're teaching class, they're on academic committees, and they have to do research and go to meetings, so they're not there for six months of the year. Instead, we hired full-time technical people. Many of them have 20 to 30 years of industrial experience, and of course, everybody has professional experience. So now, when a company calls and it's a problem that involves a chemical laboratory, we have people who work in chemical laboratories, so they understand the environment."

"NASA gave us 19 years of interfacing with customers. They gave us time to learn."

The company provides global coverage of research reports, papers, theses, journals, conference proceedings, and web-based customer services in areas such as chemical, civil, mechanical, and electrical engineering; polymer science and chemistry; biology and biochemistry; pharmacy and medicine; manufacturing; management; and government.

NERAC's dedicated mainframe computer can access more than 200 leading scientific and technical databases. Specialized search software allows multiple databases to be searched simultaneously. "We've been doing this for 33 years, so our software is extremely sophisticated," said Wilde. "We can now search 50 to 100 databases at the same time. We're always looking for new sources of information. We have all the major technical databases and business databases. And our business databases are not just produced by newspapers in order to sell photo composition tapes. Someone has read each article and has come up with an abstract that describes the information."

NERAC offers these additional services to its customers:

- **Tech Track Updates** – These updates, sent out automatically, keep customers aware of new developments in their areas of interest.
- **Table of Contents (TOC)** – This free service provides customers with access to more than 20,000 periodicals and journals worldwide. For each issue of a targeted journal that a company requests, they receive a list of articles, authors, and citation details. With TOC, customers can have access to high-priced or obscure journals without having to subscribe to each of them.
- **Business Highlights** – Management-level personnel can monitor competitors' activities and marketplace news. This service surveys business periodicals worldwide for new products and technologies coming from other corporations in the industry.
- **Patent Tracking** – Customers receive free, full-image copies of U.S. patents, European patents, European patent applications, PCT international applications, and patent abstracts from Japan. The patent files are updated weekly, so customers know if a patent has been issued or an application filed for a technology or product in their area of interest.
- **Commerce Business Daily (CBD)** – Commerce Business Daily is an early alert to federal contracting opportunities and awards.
- **Reference Plus** – This service is designed for customers who may not need NERAC's database services, but instead, may require expert consultants in a specific field. Reference Plus draws on a network of engineers in government and industry to link customers with the most appropriately qualified experts and consultants.

What About the Web?

With the explosion of the Internet, information is available to everyone with a personal computer. So, why use services like NERAC's when a world of information is at your fingertips? The answer is knowing how to search and where, according to Wilde. "Just for the fun of it, I searched the Internet for patents for electric shavers," said Wilde. "I got almost 250,000 items. I know there are not that many patents for electric shavers. I looked at the first nine items, and I found a hit from Fred Shaver, who is a patent agent. The Internet isn't professionally indexed. Our database is."

Wilde explained that the databases used by NERAC are not available free via the Internet. "If you want to get to them through the Internet, you have to pay, and usually big dollars. We have technically trained searchers. It takes us two years to train a searcher. We have a super search engine that beats the Internet search engine, and we have a third-of-a-billion items, which is more than what's on the Internet. We've done studies that show that if a company spends a half-hour a day looking for information, they should have joined our program. We do the searches, we have the databases, we have the computer, we have the experience. It's cost-effective. Time is money, so we can save companies time and money."

And, according to Wilde, the information available on-line is not always complete. "The material on the Internet is indexed by the person who puts the page up. So they try to pick index words that get lots of hits. If you have an article on a very esoteric subject in space research, it probably won't get put up on the web. So the real solid technical information doesn't get on the Internet unless some commercial organization has paid people to go out and look for it, find it, and index it. And then to get their money back, they have to charge for it."

Each week, NERAC may receive up to 250,000 new items on many subjects. The company then reviews those items for all of its customers, and automatically updates each customer in their areas of interest. "You can't get that on the Internet unless you go back and search again," said Wilde. "If you have a particular technology that you're interested in, each week we will send you only the items that are of interest to you. Our searching is extremely precise."

NERAC does use the Internet to link with its customers. The company's web site — www.nerac.com — provides each customer with a personal mailbox where they can review and select relevant citations from their NERAC searches. Called Electronic Select™, the user can order patents and view an introductory customer-training model.

But Wilde doesn't believe the Internet will ever take the place of NERAC's services. "There's no doubt the web is going to get bigger, so the amount of information accessible on the web is going to keep growing. I think it's going to grow faster than web search engines are going to be able to handle, and faster than our ability to access it. There will be even more need for our service."

And that service began as a way for NASA to get technology information out to industry and the general public. That fact is not lost on Wilde, who still recognizes the importance to any business of getting a good start. "We are very appreciative, because the NASA program gave us time to learn," he said. "In 1966, we didn't know anything. NASA gave us 19 years to get set up."

NERAC is located at One Technology Drive, Tolland, CT 06084-3900; Tel: 860-872-7000; Fax: 860-875-1749; www.nerac.com

Digital Napkins

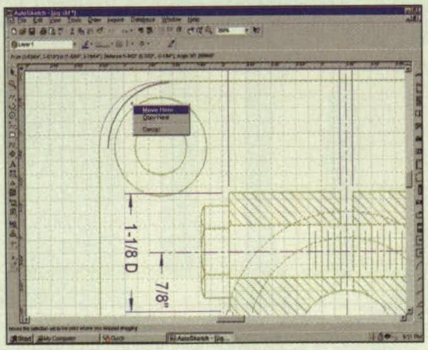
Sophisticated CAD at little or no cost.

Steven S. Ross

You know that laying out a part or charting a process should be done on a computer instead of on a napkin or piece of scrap paper. But most of you also know that CAD programs take some time to learn, you're not professional drafters, and a pencil sketch is so much faster.

Software is catching up, however, and it is clear that keeping everything on the computer saves time and money in the long run by reducing chances for misunderstandings.

Two of the best "digital napkins" are AutoSketch Release 6 from Autodesk (www.autodesk.com) and Imagination Engineer LE 2.0 from Intergraph Software Solutions (www.intergraph.com). They are both true 2D vector (CAD) programs with dimensioning. AutoSketch costs less than $100 and takes about 50 MB of hard drive space; IELE 2.0 can be ordered on CD free from Intergraph's Web site. In fact, you already may have it — IELE 2.0 is on the Microsoft Windows 98 Resource Kit CD as well. At these prices, paper napkins may be more expensive.



Full-screen view of AutoSketch drawing being modified. Note "rubber banding"effect to show you what will happen if you continue the command.

They'll run on a 486-class computer, and run well even on slow Pentiums. They each have a clear upgrade path if you need it. AutoSketch users often graduate to AutoCAD LT. There's a full-blown Imagination Engineer Technical as well. If your needs run to plant layouts, flow charts, and other system work requiring repetitive use of intelligent symbols, I suggest other drawing tools such as Visio Technical and Autodesk's Actrix.

Which one is best for you? It will depend on your specific needs, drawing style, and talent. AutoSketch is by far the more complete package right out of the box at the sub-$100 price. But many will find the sketch function in IELE compelling. It turns your mouse trail into hard-line drafting, and often guesses amazingly well.

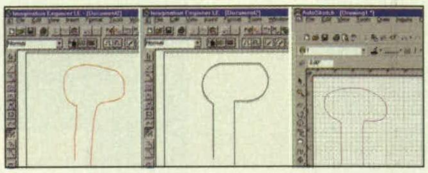
First, let's look at AutoSketch. There's not much left to chance. Knowing that many AutoSketch users will be CAD novices, Autodesk even includes a short videotape describing features and techniques. The first example on the tape is more for architects than engineers, but be patient. The tape comes to more germane topics quite quickly.

Release 5 had been a major upgrade, with optional Office 97 interface (you can keep the older "CAD style" interface if you wish), better object snaps, the ability to open and edit multiple drawings, and an application wizard that helps novices start drawings quickly. Release 6 added real-time pan and zoom, spell check, clever 3D effects, and more drawing tools. And, of course, it now imports AutoCAD R14 DWG files.

I loved the new "AutoArray" tool. Select an object or symbol (there's now a symbol bar that can display them), tell AutoSketch you want a bunch, and you get an ever-changing number of them, equally spaced, as you move the cursor. It works to space teeth around a gear hub, or chairs around a table. Another tool that reduces a complex task to the trivial is the new "Jump Snap." Let's say you need to place the axis of a rotor bearing sleeve precisely 100 mm above the baseplate, but you're not quite sure of the placement in the horizontal direction. With Jump Snap, you type in the 100 mm distance, then pick a point to start drawing the axis or place the symbol.

Pan and zoom are now dynamic — you never lose sight of the drawing as you change the view. You also can save multiple detail views and recall them at will within the same drawing. Thus, the drawing might be at a scale of 1:4 with a detail at 1:1.

AutoSketch is fully OLE compliant, so you can embed data from Excel or other programs into your drawings and edit the data in place. It also has built-in database capabilities. You can, for instance, assign a cost, weight, or color to an entity in the drawing, and query the drawing to get entities attached to that sort of specific information. It imports and exports DWG (AutoCAD binary format), DXF (a CAD standard format developed originally by Autodesk), WMF (Office-compatible Windows metafiles), and Drafix CAD files (Autodesk acquired Drafix when it purchased Softdesk several years ago). It imports older versions of the AutoSketch SKD format and exports DWF, the Autodesk Web-compatible format that can include hypertext links.


Comparison of what happens when you sketch a part in IELE (left and center), with what happens when you do it in AutoSketch.

Imagination Engineer LE 2.0 is a remarkable product, considering that it is free. You even get free support via e-mail. Intergraph hopes you will upgrade to Imagineer Technical, which lists for $495. The full product is targeted at the same price point and market as AutoCAD LT.

Both the Imagination Engineer LE and full versions have about the same drawing tools and an Office 97-like interface. But only the full version has an underlying database capability similar to the sub-$100 AutoSketch, and only the full version can save to other than IE's own IGR file format. The full version handles AutoCAD, MicroStation, and various Web formats, and can drive graphics directly from Excel spreadsheet data.

Steven S. Ross is associate professor of journalism at Columbia University, New York, NY. He has authored three commercial software packages, including a units conversion program and an engineering calculations program.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Commercialization Opportunities

Diffusing Hf and Si Into Aluminide Bond Coats for TBCs

The superior bond coats from this process enable turbine components to withstand higher operating temperatures, which in turn results in greater energy-conversion efficiencies.
(See page 49.)

Reaction-Forming Method for Joining SiC-Based Ceramic Parts

Joints can be formed with tailorable thicknesses, compositions, and thermomechanical properties thanks to a new reaction-forming process. These parts and materials are being developed for use as engine components, radiant-heater tubes, heat exchangers, components of fusion reactors, furnace linings, furnace bricks, and components for diffusion processing in the microelectronics industry.
(See page 50.)

Push/Pull Four-Point-Bending Apparatus

The present apparatus is capable of pushing on a specimen from either side and thus bending the specimen in either direction.
(See page 56.)

Noise-Reducing Fairings for Flush-Mounted Microphones

Streamlined fairings minimize noise by favoring laminar over turbulent flow. The improvement substantially reduces acoustic distortion, making noise measurements associated with wind tunnels, aircraft, air-handling equipment, and land vehicles more accurate.
(See page 56.)

Engines for Remotely Piloted Atmospheric-Science Airplanes

A spark-ignited reciprocating gasoline engine, intake-pressurized with three cascaded stages of turbocharging is currently the best solution for high-altitude subsonic missions. Production costs are relatively low because much can be borrowed from established production processes in automotive and general-aviation industries.
(See page 59.)

Mounting Heater Wires on Glass Capillary-Heat-Transfer Tubes

Two mounting schemes were devised for attaching heater wires to special-purpose glass tubing used in capillary-heat-transfer experiments. Not only are the wires required to supply heat but also the liquid and vapor enclosed by the tubing must be visible between the wires.
(See page 62.)

Hybrid Acoustic/Electrostatic Levitation Apparatus

This developmental apparatus features automation and a number of controls for levitating drops with sizes up to about 1 mm. The apparatus is suitable for growing protein crystals and cells and tissues, all under controlled conditions.
(See page 78.)

Laser Scanners Help Navigate NASA Rover

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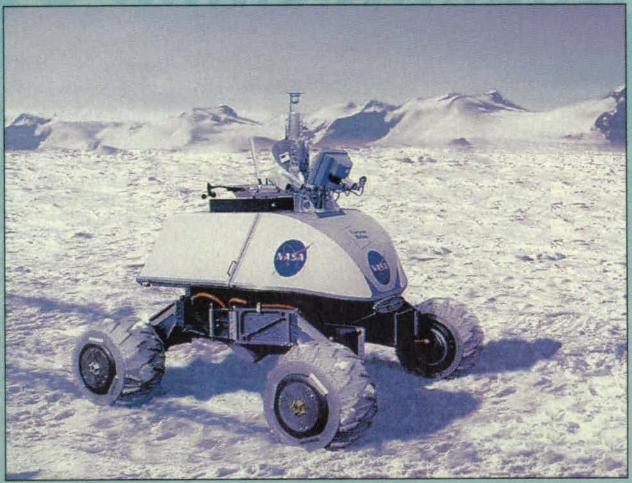
In their quest to better understand the universe, a team of geologists and other scientists from Carnegie Mellon University's Robotics Institute, the University of Pittsburgh, and NASA's Ames Research Center are using the LMS laser measurement system to search for meteors. The team is involved in searching for and classifying rocks and meteorites in the Antarctic, and examining the possibilities of autonomous navigation by a Nomad rover. The team is being assisted by the Chilean Air Force and scientists from the Chilean Antarctic Institute.

The specially designed all-terrain Nomad rover, the Amadeus, is being used to navigate the treacherous terrain. Navigational problems include weather and environmental factors, such as blue ice fields, snow, moraines, crevasses, rocks, and other obstacles. The Amadeus must be able to autonomously navigate any of these conditions, or navigate with minimal human guidance. The vision system on the Amadeus consists of two stereoscopic cameras and a 180-degree SICK Laser Measurement Scanner (LMS). The LMS proximity laser scanner is a non-contact measuring system that scans its surroundings two-dimensionally. It requires no reflectors or positional markers, and measurement data from the LMS is available in real time.



The Amadeus rover is equipped with a laser measurement system for navigating around objects and through extreme weather and environmental conditions.

The LMS operates by measuring the time-of-flight of laser light pulses. A pulsed laser beam is emitted and reflected if it meets an object, and the reflection is registered for evaluation by the scanner's receiver. The pulsed laser beam is deflected by an internal rotating mirror so that a fan-shaped scan is made of the surrounding area. The time between transmission and reception of the pulse is directly proportional to the distance between the scanner and the object, while the contour of the object is determined from the sequence of received pulses. The LMS is able to cut through fog, snow, and rain and continue to see the actual terrain that lies ahead of the Amadeus rover when the cameras may be blinded.

For More Information Circle No. 741

Packaging Film Protects Astronaut Meals

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Wolff Walsrode, a unit of Bayer Corp., supplies NASA with Combitherm XX film as packaging material for the freeze-dried meal components served to astronauts on Space Shuttle missions. The nylon-based co-extruded film — made from Bayer's Durethan® polyamide 6 resin — also is used to protect many of the snack items carried onboard the spacecraft, including dried fruits, cookies, nuts, and candy.

About five months prior to their scheduled launch, the shuttle astronauts compile their personal menus from a large selection of food and beverages. Depending upon the type and shelf life of the products, the food is provided either in natural or processed form. About a month before launch, the food and beverages are packed and stored in drawers that fit into the shuttle's supply storage system. The weight of packaging material for all food on the Space Shuttle is limited to just 450 grams per person per day.

This "blue-plate special" of shuttle astronaut foods is protected by Combitherm XX packaging film.

The FDA-approved, transparent, thermoformable film is used not only for food packaging, but also for storage and other applications on the Space Shuttle. The films also are being evaluated for use in the International Space Station.

For More Information Circle No. 742

Special Coverage: CAD/CAE/PDM

ParVox — a Parallel-Processing Software for Volume Rendering of Data

Users could view results of simulations and modify underlying mathematical models "on the fly."

NASA's Jet Propulsion Laboratory, Pasadena, California

ParVox is a distributed visualization system consisting of a rendering core running on a parallel computer and a graphic user interface program (GUI) running on a Unix workstation. The ParVox system is designed for interactive, distributed visualization of large multiple time steps, multiple-parameter volume data sets: data sets that are impractical or impossible to visualize on workstations.

The following requirements were identified from discussion with scientists and are the basis for the design of ParVox:

1. Able to visualize a pregenerated volume data set interactively in three-dimensional (3-D) space or animate pregenerated multiple time-step volumes. Current visualizations include translucent colored volumes, isosurfaces representing threshold values, and 3-D slices of data.
2. Provide an application programming interface (API) for linking into applications. The API allows applications to render 4-D (spatial and time) volumes with predetermined parameters, such as classification, viewing transformation, shading, and lighting. Storing intermediate simulation results as rendered images greatly reduces the disk storage and the transmission time to the user's workstation.
3. Able to run in concert with the data generating application, all under the control of the GUI. This allows the researcher to view the model result while it is being generated and thus adjust the model parameters accordingly. This mode acts as both a visualization system and a debugging tool for the simulation by allowing analysis of results on the fly.

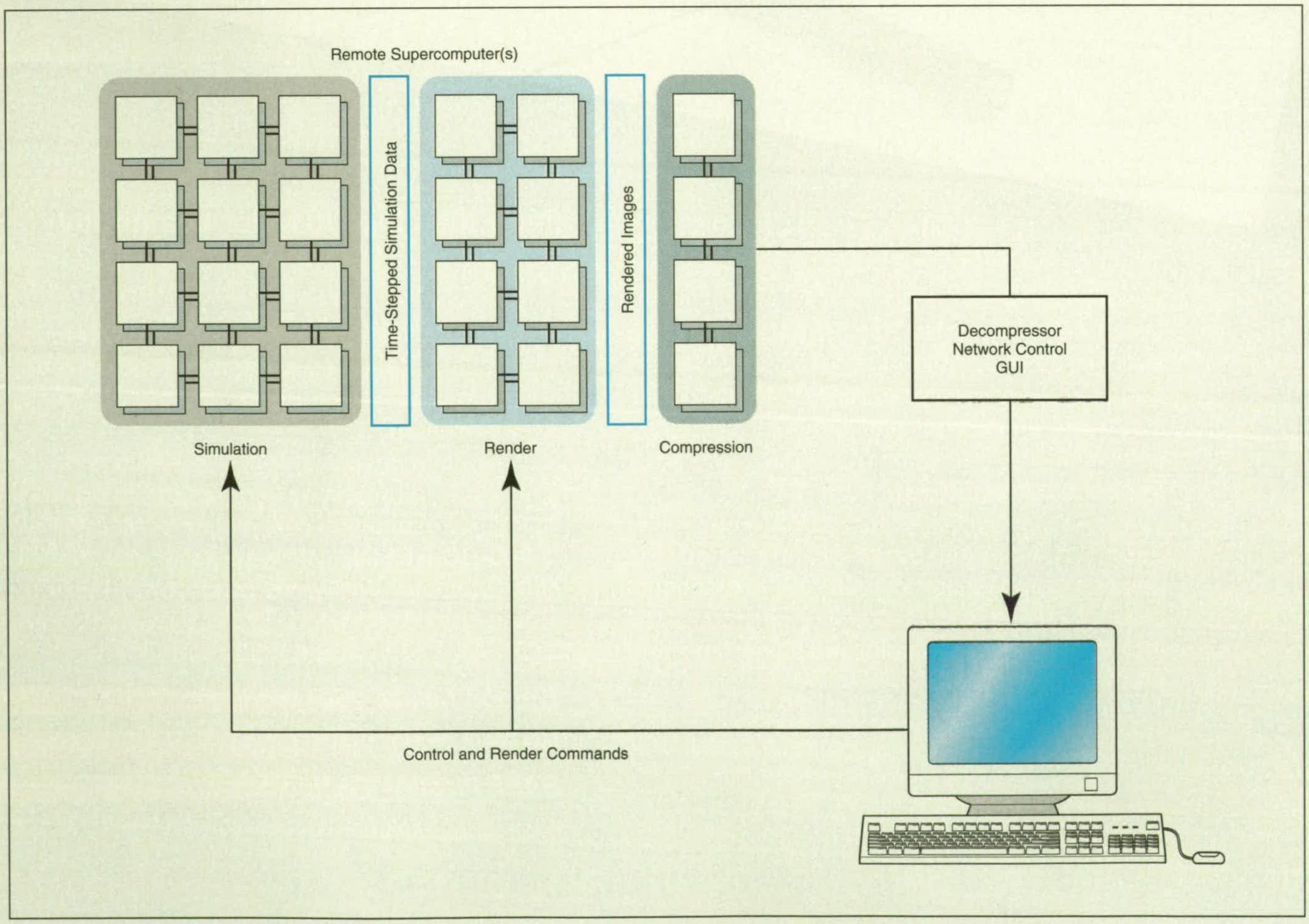

Figure 1. **ParVox Pipelining Architecture** allows the parallel computer to partition its resources optimally.

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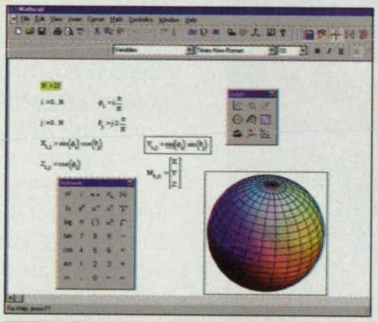

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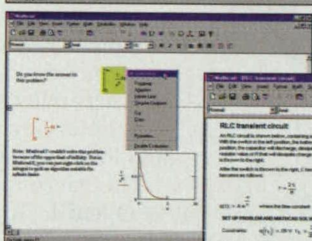

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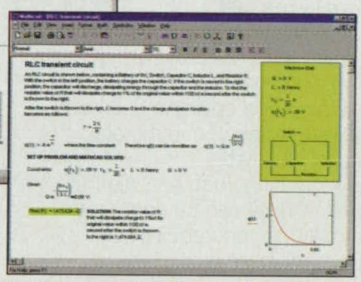

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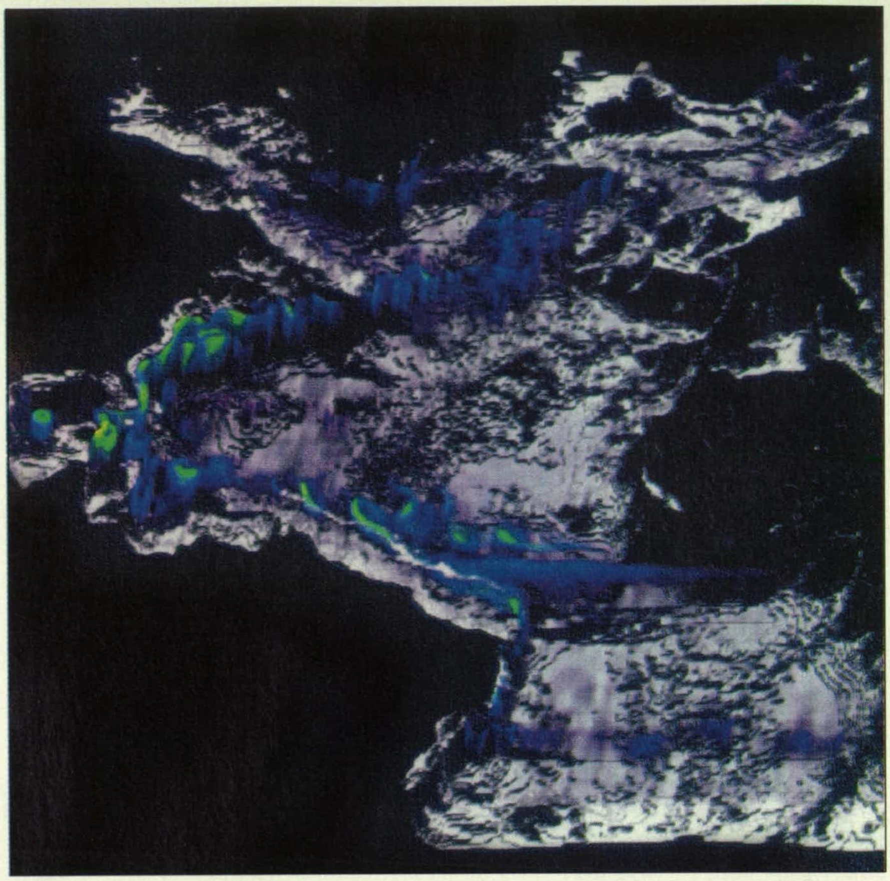


Figure 2. **Atlantic Ocean Current Velocity Volume Data** are shown with ocean floor topological map.

ParVox is designed to fulfill all of the above requirements. Currently, two of the three requirements have been implemented: It is able to visualize pregenerated data and has a full-featured rendering API.

As a post-processing distributed visualization system, it provides an X Window based GUI program for display and viewing control, a parallel input/output library for reading and writing 4-D volume data sets, a networking interface program that runs on parallel computer and calls the rendering API in response to the GUI workstation, and a parallel wavelet image-compression library that supports both lossless and lossy compressions.

The ParVox rendering API is similar to OpenGL. It includes lighting, shading, classification, data redistribution, multiple isosurfaces, multiple slices, direct volume rendering, multiple variable and multiple time-step volume rendering. It uses the "Splatting" algorithm, which is a feed-forward voxel projection algorithm.

A functional pipelining architecture is proposed to handle the third requirement (see Figure 1). This allows the parallel computer to partition its resources optimally for the simulation process and the rendering process separately.

The core ParVox is a scalable, efficient, parallel volume rendering API. Both object-space decomposition and image-space decomposition are used to assure balanced computational loads among parallel processors. An asynchronous, one-sided communication scheme is used for data transmission from splatting processors to compositing processors. The communication and synchronization overhead are minimized by overlapping the data transmission and computation.

ParVox is running on the Cray T3D and T3E supercomputers using Cray's shared memory (shmem) library. It is being ported to the Message Passing Interface Standard (MPI2.0); therefore, it will be portable to other supercomputer platforms. ParVox has been successfully used by JPL researchers in visualizing the Atlantic Ocean Current Simulation data (see Figure 2), the Thermal Convection Modeling data, and the BEAM (Beacon-based Exception Analysis for Multimissions) difference maps.

This work was done by P. Peggy Li and James Tsiao of Caltech and Scott Whitman of Equator Technology for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Information Sciences category. NPO-20348*

Improvements in Generating and Using Unstructured CFD Grids

A grid generation code accepts data directly from CAD software.

Lewis Research Center, Cleveland, Ohio

Some recent and continuing efforts to develop a software system for simulations of flows in gas-turbine combustors by Computational Fluid Dynamics (CFD) have addressed such major issues as the integration of CAD (Computer Aided Design) data for grid generation purposes. The generation of coordinate grids for use in flow-field computations is a major issue due to its time-consuming nature. The direct use and import of CAD data is important so as to remain true to the geometry and to reduce the user time necessary in generating the computational grid.

The software package CFD-GEOM, developed by CFD Research Corporation, has been modified to accelerate and optimize the generation of unstructured grids. [As used here, "unstructured" means having cells that are irregularly shaped and/or not necessarily connected in any particular sequence and are related to each other in arbitrary ways that must be specified explicitly.] The overall result was to provide within CFD-GEOM a fast and high-quality unstructured grid-generation capability. CFD-GEOM can generate grid combinations (i.e., hybrid grids) of tetrahedral, prismatic, and multiblock structured grids. The ability to generate those grids efficiently is of crucial importance to the NASA Lewis National Combustion Code, which supported some of those developments.

A critical factor in obtaining overall end-user efficiency is the access to the original CAD geometric description of the gas-turbine combustor. CFD-GEOM has incorporated several paths in which CAD data can be accessed and used. CFD-GEOM has implemented a robust IGES reader to enable the incorporation of CAD data stored in the IGES format. IGES is an international standard, enabling transfer of geometric CAD data between organizations if the CAD data base is not directly accessible. If the CAD data base is directly accessible, CFD-GEOM can obtain the geometric information from the data base without the need for IGES translation. This enables the grid-generation process access to the true CAD data without any inaccuracies which may occur through the IGES translation. Such a direct link also enables

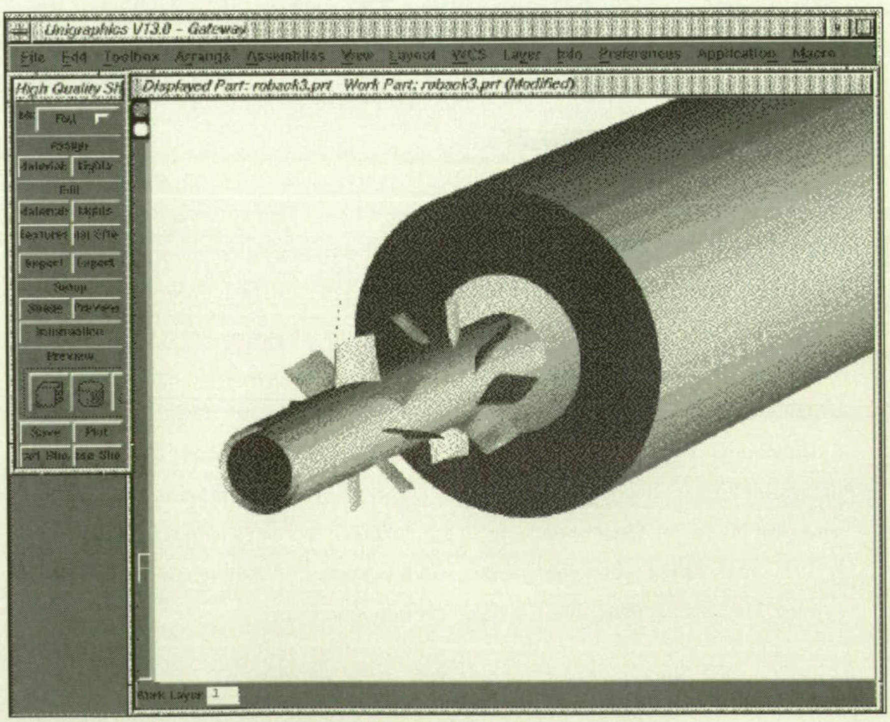


Figure 1. This is the original **Unigraphics CAD Model** of a vane configuration.

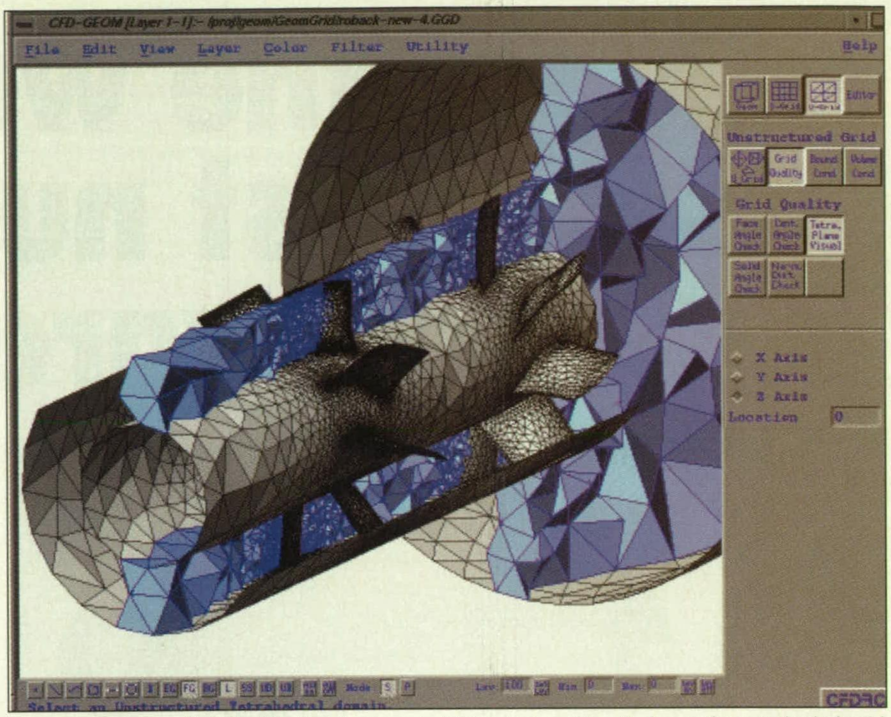


Figure 2. This is a **CAD Model**, directly imported from Unigraphics. It shows the tetrahedral grid generated by CFD-GEOM.

modifications made by the designer to be quickly received by the grid generator CFD-GEOM and incorporated into a CFD model.

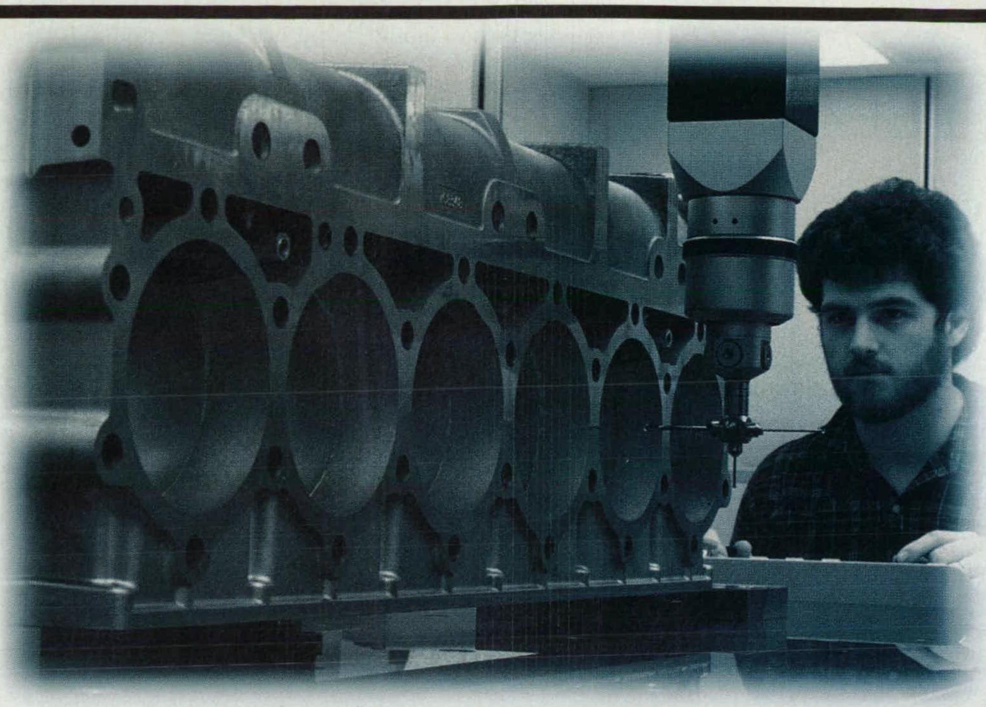
CFD-GEOM, in collaboration with NASA Lewis, established a direct link with the Unigraphics CAD design system for transferring combustor design data directly to CFD-GEOM. This direct link allows combustor design engineers to access the data from Unigraphics directly in its true form. By accessing the data in this manner, CFD-GEOM is able to define surface sets, a collection of trimmed NURBS (Non-Uniform Rational B-Spline) surfaces which define a closed air-volume. The automatic definition of the surfaces which define this "air-volume" is crucial for the grid-generation process.

To prepare the geometric model for CFD (and other engineering) computations, a suitable grid must be generated to discretize the domain. For this purpose, CFD-GEOM has an automated (and controllable) unstructured grid-generation method which directly generates the grid on the trimmed NURBS model definition. The triangular surface mesh is generated on the NURBS surfaces using four constraints: maximum element size, transition factor (both are user specified), surface curvature criteria, and smallest geometric feature. The surface curvature criteria allows the user to specify how closely the surface needs to be approximated (i.e., more smaller elements in regions of high curvature). Once the initial surface mesh has been created, the user has the option to locally refine the surface grid as desired.

After a suitable triangular surface mesh is obtained, the volume grid-generation process can begin. Two options are available (1) generate a full tetrahedral mesh or (2) generate a prismatic grid by advancing the triangular cells into the normal direction of the surface over a certain user-specified distance and density. The latter option is usually combined with a tetrahedral mesh (i.e., hybrid volume grid) for the remainder of the computational domain. For the tetrahedral volume mesh generator, the user can control the grid density by using source parameters in the volumetric domain.

During the CFD-GEOM code-development process tremendous improvements have been made in speed and quality of the surface and volume mesher. A speed of 200,000 to 300,000 grid cells per minute is typical on high-end workstations, while grids with a minimal center-to-face angle of 15° can be reached for complex geometries. Both criteria are considered to be excellent values.

Using the procedure outlined, a significant reduction in time required to perform one gas-turbine combustor analysis cycle is evidenced. By directly accessing the data from the Unigraphics system (which is commonly used by some engine manufactures), the time



required to do model set up has been minimized. With the use of fast and automatic grid-generation techniques, the time required for grid generation has been significantly reduced. In addition, high-quality grids tend to help the flow solver convergence process (fewer iterations on an iterative algorithm).

A demonstration of CFD-GEOM capabilities is given in Figure 1, which shows the original CAD model of a vane configuration within the Unigraphics CAD system (CAD model courtesy of Pratt & Whitney). Figure 2 depicts the resulting surface mesh and a slice of the tetrahedral field grid.

This work was done by John Whitmire, Tim Dollar, Vincent Harrand, and Curtis Mitchell of CFD Research Corporation for **Lewis Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Information Sciences category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16583.

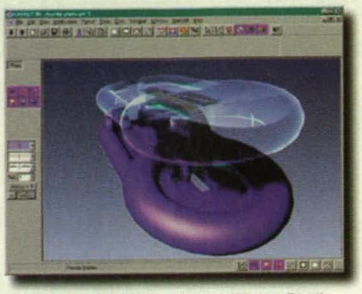
Easy-to-Use Software for Planning and Scheduling

NASA's Jet Propulsion Laboratory, Pasadena, California

The Automated Planning and Scheduling Environment (ASPEN) version 2 computer program comprises a modular, reconfigurable software framework and collection of software components that can be used for automated planning and scheduling in a variety of applications. ASPEN can automatically generate schedules pursuant to high-level goals specified by the user. ASPEN can also provide automated assistance, with human intervention, in the correction of previously generated faulty schedules. The primary advantages of ASPEN are simplicity and ease of use. Features include a heuristic specification language to provide guidance for the automatic-scheduling software components, an external function interface that facilitates integration with other software, and a graphical user interface for viewing and manipulating schedules. ASPEN was written in C++ for execution on a Sun Workstation running Solaris 2.5-2.6 with at least 32MB of random-access memory and 1GB of disk storage. The Objectspace STL Library and Java Runtime Environment are necessary for execution. The graphical user interface (GUI) can also be run on a PC with the Java Runtime Environment.

This work was done by Robert Sherwood, Steve Chien, Gregg Rabideau, Anita Govindjee, Alex Fukunaga, David Yan, and Russell Knight of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Software category.* *NPO-20299*

Special Coverage: CAD/CAE/PDM



Photorealistic Rendering (Photo-Real)

CADKEY 98 **3D/2D CAD software** from Baystate Technologies, Marlborough, MA, is available for Windows 95/98/NT 4.x. It integrates FastSOLID™ and ACIS® 4.2 solid modeling technology, and features enhancements such as multiple document interface (MDI), a Smart Cursor, and CADKEY 3D Viewer. Also included is Photorealistic Rendering for creating life-like images of 3D models, using a variety of colors, textures, and materials.

New capabilities include lofted solids, variable radius blending, and advanced spline, plane, vector, and point creation features. The software incorporates a new STEP™ translator to import/export CAD data using STEP AP203 standards.

For More Information Circle No. 717

Parametric Technology Corp., Waltham, MA, has introduced Windchill Release 2.0 **product and process management software** with Web-based workflow capabilities, allowing users to accelerate the flow of product and process information throughout the enterprise. It allows management across functions of all phases in a product lifecycle, from concept and definition, to production, service, maintenance, and retirement.

The software graphically depicts and validates a company's workflow processes. It provides a variety of options for distributing information to workgroup members, for structuring activities, and for monitoring progress on tasks. It also features enhancements to the Windchill Lifecycle Application Suite PDM Package, which supports product structure management, bill of materials view management, and change management.

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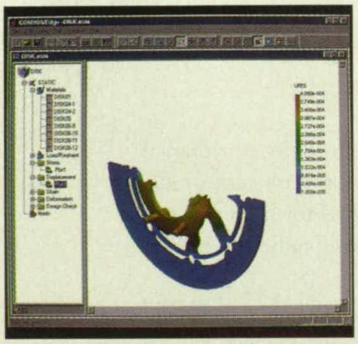

COSMOS/Edge™ 3.0 **design analysis software** for Solid Edge from Structural Research & Analysis Corp., Los Angeles, CA, is a modular program that allows Solid Edge users to analyze whole assemblies automatically, rather than individual components. Working inside Solid Edge, the new software provides drag-and-drop analysis of boundary condition, material information, and result plots from one analysis to another.

Other features include a Design Check Wizard, which allows users to determine whether designs will meet their yield strength criteria; OpenGL visualization for graphical analysis information such as sections, surfaces, and contours; and Internet-ready report generation in HTML, TXT, AVI, and VRML formats.

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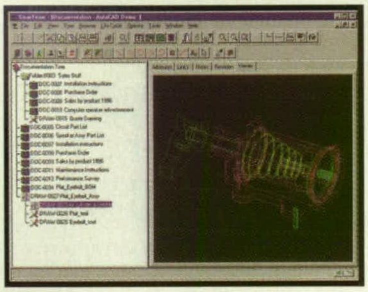

SmarTeam, Beverly, MA, offers Rev 2.5.03 of SmarTeam™ **product data management (PDM) software** that automates management of data via seamless integration with mission-criticial applications. The software enables users to view over 150 CAD, office, and raster file formats, including AutoCAD DWG, DXF, HPGL, Microsoft Word®, and Microsoft Excel®. Ready-to-use templates include mechanical engineering, office automation, process organizations, and others.

Using Open Document Management Architecture (ODMA), the program can be integrated into any Windows CAD and office software. Available CAD plug-in tools include: SmarTeam-Works, a PDM module for SolidWorks® users; SmartDesk for users of AutoCAD® and Mechanical Desktop®; SmartKey for users of CADKEY®; and SmartEdge for users of Solid Edge®.

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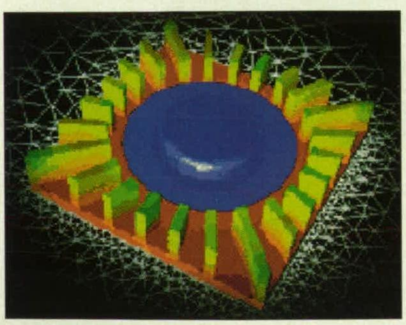
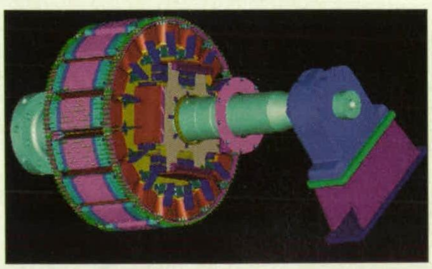


Fluent, Lebanon, NH, offers Icepak **thermal analysis and design software** for electronics cooling. The software supports a direct interface with Pro/ENGINEER mechanical design software from Parametric Technology Corp. Icepak allows engineers to build a computer model of a product or system design, then virtually prototype it, testing it under real-world conditions to verify designs.

The software allows users to optimize designs by predicting cooling at the component, board, and cabinet levels. The Pro/E interface enables designers to define the thermal model within Pro/E. The interface module works with Pro/E versions 19 and 20, and exports model data that can be directly read into Icepak version 2.2.

For More Information Circle No. 718



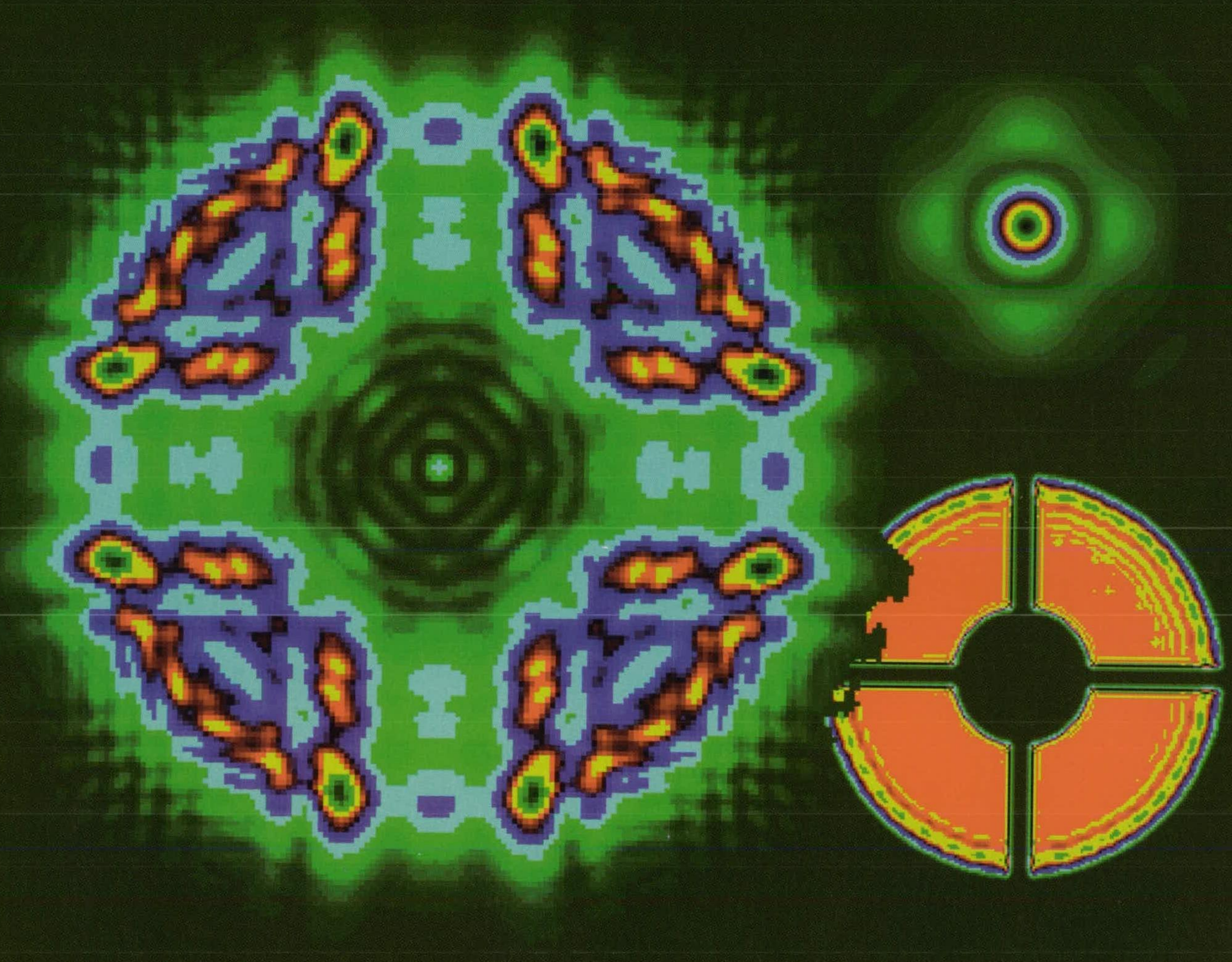
CSC/Microcadam, Los Angeles, CA, has introduced Helix98, an enhancement to the Helix Design System™ **CAD software**. The new program includes the Executive Version of ViaVoice™ 98 voice-actuated 3D design software from IBM. Designers eliminate the need for scrolling with a mouse and using pull-down menus.

Helix 98 users can design models by saying commands such as "extrude," "shade," and "save." Voicing commands eliminates icon tool bars, providing more screen space to view designs. The software works with a computer equipped with Audio User Input (AUI) for voice actuation.

For More Information Circle No. 719

March 1999

PHOTONICS Tech Briefs



Using Gaussian Beam Decomposition

Highly Stable Lateral-Transfer Retroreflectors

Low-Distortion Imaging Spectrometers

New Photonics Products
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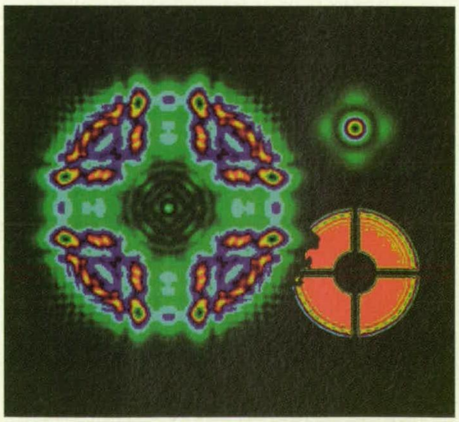

On the cover: Images derived from irradiance calculations using the Gaussian beam decomposition technique. *Design and art work courtesy Breault Research Organization.*

Using Gaussian Beam Decomposition

A new method for optics calculations unifies geometrical and physical optics.

Geometrical optics and physical optics are two entirely different approaches to solving optical problems. Geometrical optics is about tracing rays, Snell's law, reflections, distances, and angles. In contrast, the world of physical optics is about complex mathematical manipulations: Fourier transforms, differential equations, or matrix propagators. It almost seems as if these two approaches are describing two different phenomena. In recent years, however, a new method of performing optics calculations has arisen that unifies geometrical and physical optics within a simple mathematical formalism. This is the method of Gaussian beam decomposition.

The idea behind Gaussian beam decomposition is to decompose an arbitrary optical field into a coherent superposition of Gaussian beams.

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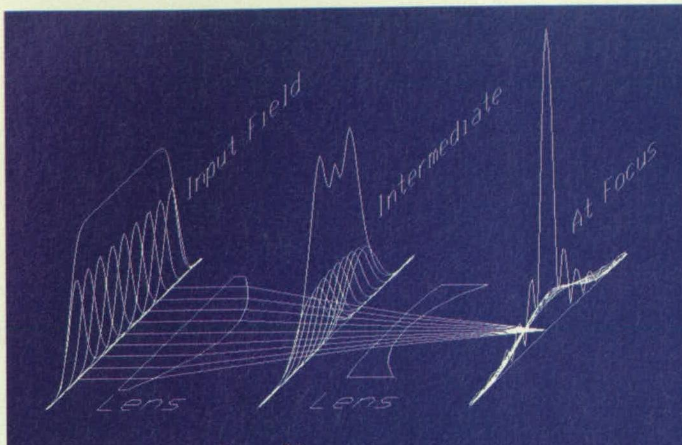


Figure 1. Illustration of how an arbitrary input field can be represented as a superposition of Gaussian beams.

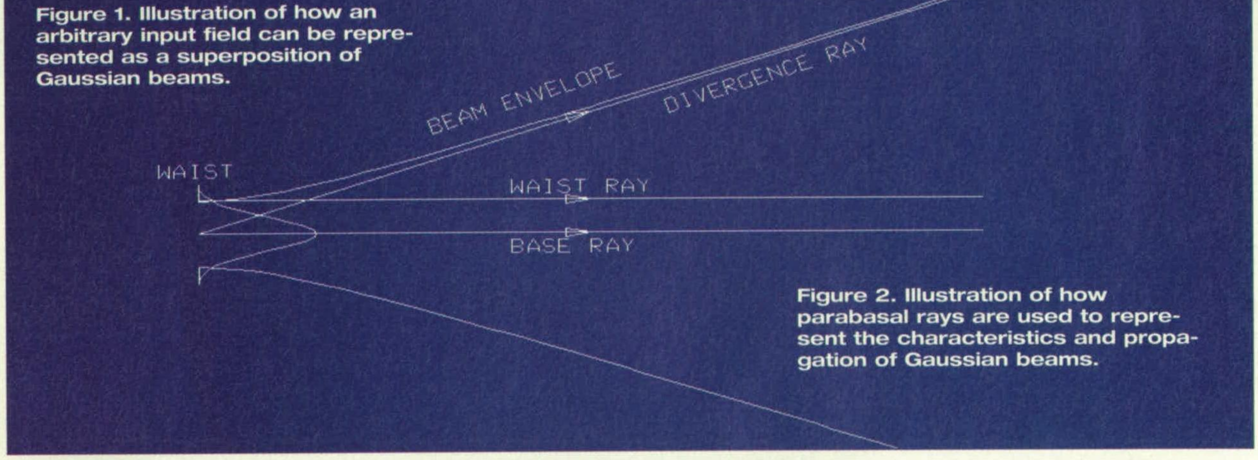


Figure 2. Illustration of how parabasal rays are used to represent the characteristics and propagation of Gaussian beams.

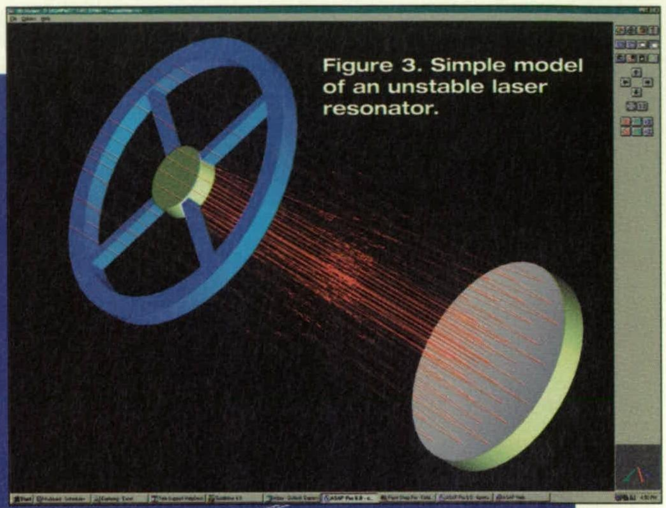


Figure 3. Simple model of an unstable laser resonator.

Figure 1 illustrates this idea. The flat field on the left is broken into a series of Gaussian beams. The advantage to doing this is that propagation of Gaussian beams is well understood. Such beams retain their Gaussian profile as they propagate through free space. In fact, if the local curvature of a lens or mirror is gentle, then Gaussians even retain their shape after reflection or refraction from a mirror or through a lens. As a result, if the location, size, divergence, and phase of each beam is tracked as it is propagated, then the field can be reconstructed across any plane between and up to the final image plane, as illustrated by the middle and right-hand fields shown in Figure 1.

Base and Parabasal

This method only works if there is a practical way to propagate Gaussians through optical systems. It so happens that propagation of the Gaussian beams can be done with standard ray-tracing techniques. This is because there is a one-to-one relationship between propagating Gaussian beams through an optical system and tracing rays. Figure 2 illustrates this idea.

The location and direction of the beam is represented by a single ray,

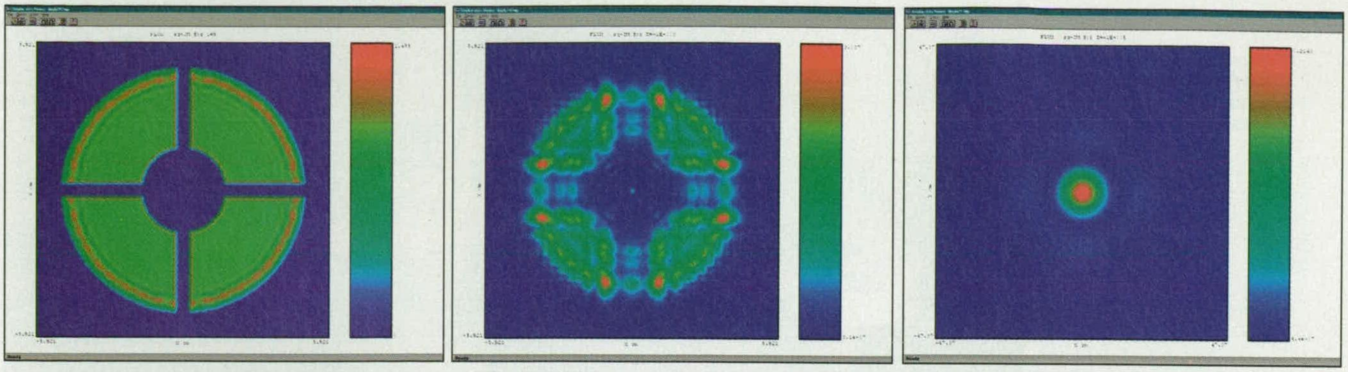


Figure 4. Irradiance calculation of the output from an unstable resonator at three propagation distances: from left, 1 cm, 1000 cm, and 100,000 cm.

called the base ray, at the peak of the Gaussian. Two additional rays, known as parabasal rays, together define the size and divergence of the Gaussian. These rays are traced in parallel with the base ray, so that the effect of refractive and reflective optical components on the size and divergence of the associated Gaussian beam is properly accounted for. Two additional parabasal rays are defined in a plane that is orthogonal to the first two. This permits the Gaussian to have a different diameter and divergence in the two dimensions.

Of course, as the base and parabasal rays are traced, they become thoroughly tangled together. Nevertheless, mathematical relations between the locations and directions of the base and parabasal rays and the size and divergence of the Gaussian beams exist that allow the Gaussian beams to be reconstructed at any point.

There are many advantages to this approach. First, because geometrical and physical optics calculations are both based on tracing rays, geometrical and physical optics propagation is now done through the single geometrical model. Second, the practical use of this method is simple: no matrix propagators, no complex field arrays, no differential equations, no Fourier transforms. Third, beamsplitting and recombination are combined within a single formalism. Beams approaching a partially transmitting component are simply split into reflected and transmitted components. These are then brought together to produce interference effects.

Fourth, nonsequential propagation through complex three-dimensional optomechanical geometries is now much simpler. The base and parabasal rays are simply traced in the usual way without regard to concepts such as an axis of propagation. Finally, by attaching polarization to each Gaussian beam, polarization effects, such as bire-

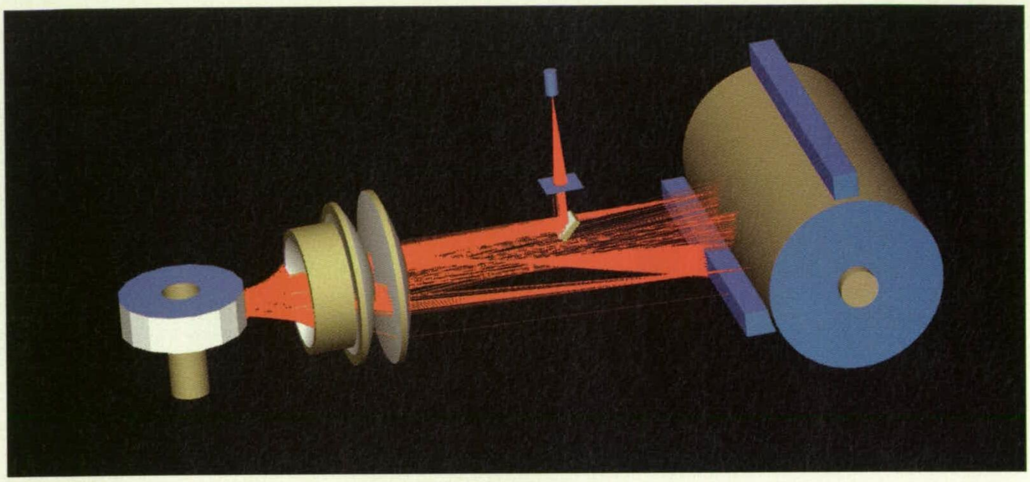


Figure 5. Illustration of nonsequential beam propagation through a laser printer model.

fringence, can be carried with each beam and included in the final superposition of the field.

An Approach that Works

Does this approach work? In a word, yes. Figures 3 and 4 show a model of an unstable laser resonator, and propagation of the output at three propagation distances. Initially, the central obscuration and spider shadows are clearly imprinted on the beam. After propagating 1000 cm, complex diffraction phenomena appear, including a spot of Arago in the center of the obscuration. After propagating 100,000 cm, a far-field pattern is produced that is reminiscent of a classic Airy-disk pattern.

Propagation through a complex three-dimensional geometry is illustrated in Figure 5. Here light is propagated nonsequentially through a laser printer model.

The Gaussian decomposition method is most appropriate for workers who do diffraction calculations in systems that have no axis of symmetry, or systems that have three-dimensional apertures and obscuration, or for those who must propagate fields that are not Gaussian or flat-top. These types of systems do not have a single well-defined exit pupil, so traditional Fourier transform techniques are difficult to use. Also, matrix methods are often cumbersome when there is not a single optical axis.

Gaussian decomposition is also useful to designers or users of interferometers. These workers must understand the interference patterns produced by ghosts or component misalignments and tolerances. In these systems, base and parabasal rays are split at partially transmitting surfaces during a nonsequential ray trace, and both parent and ghost rays are traced to the focal plane. Gaussian beamlets are then synthesized from these rays at the focal plane, and superposed to calculate the total field,

including all interference effects. Tracing the base and parabasal rays is easy with modern nonsequential ray tracers, but complex three-dimensional folds and component tilts make it difficult to define a unique propagation axis or pupil location for standard Fourier transforms or matrix propagation methods.

Gaussian beam decomposition is an easier approach to performing physical optics calculations within a wide class of fully three-dimensional systems. Because the method is based on ray tracing, users are freed of concerns about propagation axes, differential equation stability, and aliasing. In fact, in most conventional optical systems, performing a wave optics calculation is not much more difficult than the geometrical calculations that are so familiar.

For more information, contact Gary L. Peterson, the author of this article, at Breault Research Organization Inc., 6400 East Grant Rd., Suite 350, Tucson, AZ 85715; (800) 882-5085; (520) 721-0500; fax: (520) 721-9630; E-mail: gpeterson@breault.com; www.breault.com.

 For More Information Circle No. 465

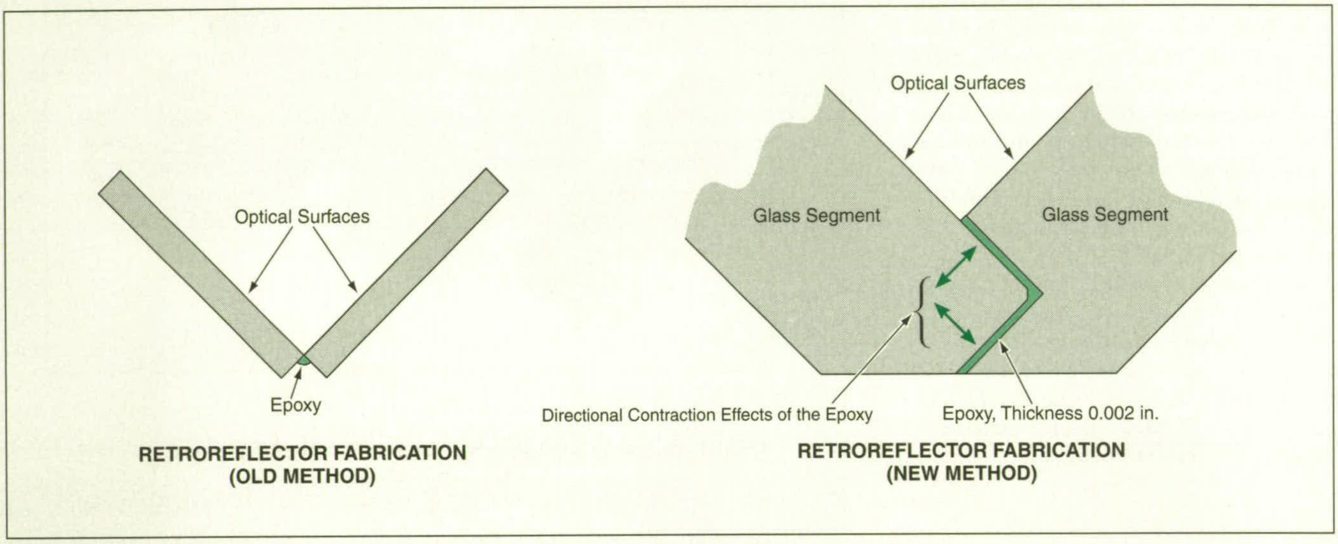
Highly Stable Lateral-Transfer Retroreflectors

Thermally induced beam deviations can be limited to the arc-second range.

Goddard Space Flight Center, Greenbelt, Maryland

Lateral-transfer optical retroreflectors can now be made extremely stable to both external and internal fluctuations and gradients of temperature. As explained in more detail in the fourth paragraph, this high stability is achieved through improvements in design and fabrication.

A lateral-transfer retroreflector is similar to the more familiar corner-cube reflector in that (1) it includes three optically flat mirrors co-aligned and bonded in place so that each optical face is perpendicular to the other two faces and (2) by virtue of this mutual



The **Differences in Fabrication** are compared here for the earlier and improved retroreflector designs.

perpendicularity, regardless of its orientation, it always reflects a beam of light back along a line parallel to the direction of incidence. However, unlike in a corner-cube reflector, only two of the mirrors are adjacent. The third mirror is mounted out on an arm, away from the other two mirrors, so that the retroreflected light beam is displaced laterally from the incident light beam by a distance that depends on the length of the arm. Thus, a lateral-transfer retroreflector is useful for picking off a portion of a light beam and sending it back to a location laterally displaced from the source.

Heretofore, in the fabrication of a retroreflector, the usual practice has been to bond the mirrors together by use of epoxy along back seams as shown on the left side of the figure. When the retroreflector is then subjected to a temperature below the fabrication temperature, the epoxy shrinks, giving rise to tensile stresses on the backs of the mirrors. These stresses cause the mirrors to undergo angular misalignments that are small but nevertheless unacceptable because they give rise to degradation or loss of the retroreflective optical function.

In the improved design, the seams (where the faces are bonded) have a tongue-in-groove configuration, which makes it possible to put epoxy on two different surfaces in each seam. This configuration (depicted on the right side of the figure) causes the stresses engendered by cooling the retroreflector to below the fabrication temperature to become distributed across two planes perpendicular to each other. The result is a bond that does not allow change in either direction because the epoxy is essentially working against itself and unable to pull the mirrors out of alignment.

As part of a demonstration of this concept, a lateral-transfer retroreflector with a beam deviation of 11 arc seconds and a peak-to-valley wavefront error of 0.3 wave at a wavelength of 633 nm was constructed. The beam deviation was shown to change by less than 1 arc second when the retroreflector was subjected to an internal temperature gradient characterized by a temperature difference of 30 °C between the seam of the dihedral mirror subassembly and the mirror at the other end of the arm.

This work was done by James J. Lyons III of **Goddard Space Flight Center.** *No further documentation is available.*
GSC-14056

Inflatable Fresnel Lenses as Concentrators for Solar Power

Primary advantages would be light weight and tolerance of shape errors.

Lewis Research Center, Cleveland, Ohio

Inflatable Fresnel lenses are being developed for use as optical concentrators in solar power systems. These lenses are of two types: dome (point-focus) lenses and cylindrical (line-focus) lenses (see Figure 1). Originally intended for supplying power to spacecraft, these lenses might also be adaptable to some terrestrial solar-power systems in cases in which optical aberrations caused by gravitational and wind-loading distortions of lens shapes could be tolerated.

The main structural element of a dome lens concentrator would be a spherical balloon. The balloon would be made of a polymer (*e.g.*, polyethylene terephthalate) film about 12 μm thick, possibly coated with aluminum on both sides everywhere except in the dome lens region. The concentric prisms that constitute the Fresnel lens elements could be molded into a sheet that would be bonded to the inner surface of the balloon; typically, this Fresnel-lens sheet would be cast from clear silicone rubber and would be about 250 μm thick. In practice (at least initially) it could be desirable to approximate the desired spherical shape by assembling the balloon and Fresnel lens from gores. At a latitude chosen consistently with the focal length and the radius, the balloon would be anchored on a back plane that would support the solar receiver and would serve as a radiator for dissipating waste heat.

A paraboloidal dish reflector is the main competitor to an inflatable dome lens concentrator. The most obvious advantage of an inflatable dome Fresnel-lens concentrator is that a large concentrator surface can be established and maintained readily by inflating a lightweight balloon, whereas a paraboloidal dish rigid enough to maintain the required shape weighs considerably more. Another less obvious but equally important and concomitant advantage is that in comparison with a paraboloidal reflector of nominally equal area and relative aperture, a dome Fresnel lens can be made considerably more tolerant of shape error (see Figure 2); for a typical slope error at the outer edge of the lens, the spreading of the solar image is less than a hundredth of that caused by the same slope error at the outer edge of the reflector.

A cylindrical Fresnel-lens concentrator would be essentially a simplified, two-dimensional version of a dome Fresnel-lens concentrator. The dome Fresnel-lens concentrators would be well suited for applications in which there is a requirement for aperture sizes of the order of meters for photovoltaic, thermophotovoltaic, and various types of thermal solar receivers. The cylindrical Fresnel-lens concentrators would be suitable primarily for aperture widths of 5 to 10 cm for linear arrays of photovoltaic cells.

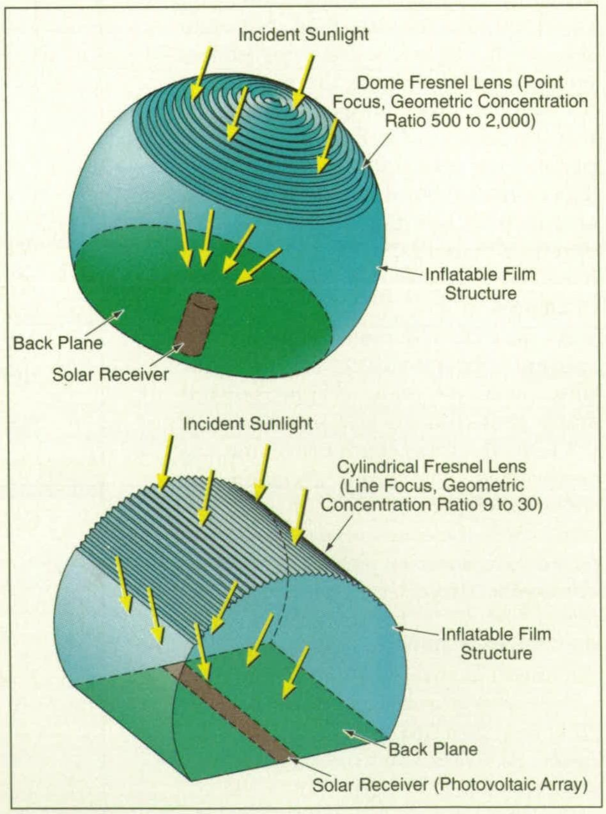


Figure 1. **Fresnel Lenses** would be supported on the interior surfaces of spherical and cylindrical balloons. The spatial intervals between Fresnel-lens prisms are greatly exaggerated in these views.

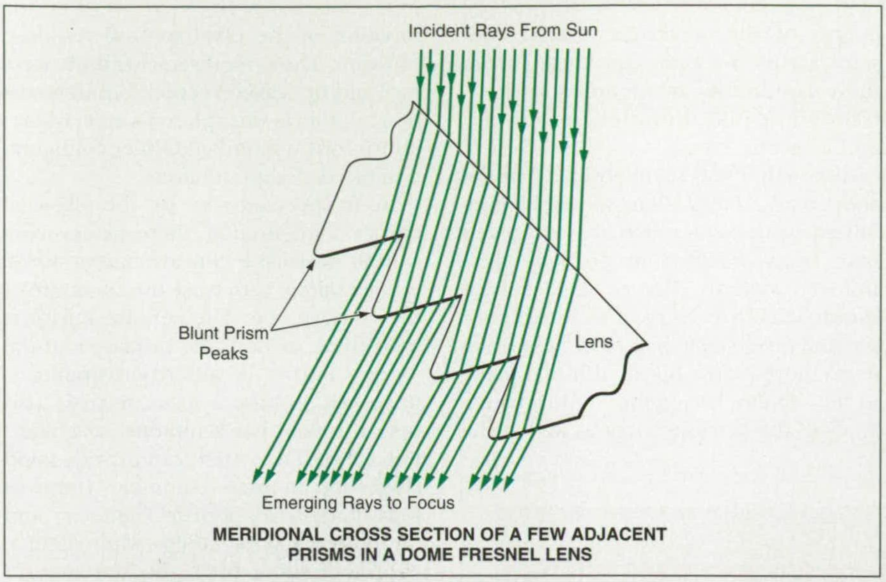


Figure 2. A **Symmetrical-Refraction Design** (in which the angle of incidence equals the angle of emergence) maximizes the tolerance to slope error in that it minimizes the deviation of the angle of refraction for a given slope error. An additional benefit of the configuration shown here is that the blunt prism peaks are tucked out of the ray paths and thereby prevented from scattering light.

This work was done by Mark J. O'Neill and A. J. McDanal of ENTECH, Inc., for **Lewis Research Center**. *No further information is available.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16662.

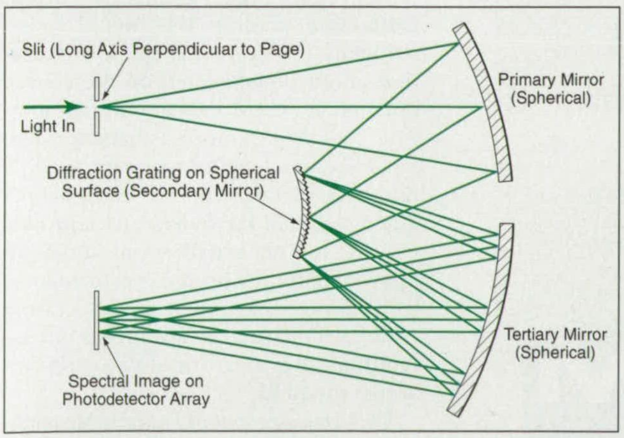
Low-Distortion Imaging Spectrometers

Distortion would be minimized by use of modified Offner optics.

NASA's Jet Propulsion Laboratory, Pasadena, California

"Pushbroom" imaging spectrometers of a proposed type would exhibit little or no distortion in either the spectral or spatial direction. These spectrometers would feature modified Offner optics, which afford a desirable combination of compactness and a high degree of optical correction. Although Offner optics have been used in some spectrometer designs, their potential for eliminating distortion does not appear to have been exploited.

A pushbroom spectrometer includes a rectangular photodetector array with pixels arranged in rows (parallel to a spatial axis defined by a straight slit) and columns (parallel to the spectral axis). Light enters the spectrometer through the slit. Each point or pixel along the slit corresponds to a point or pixel along one spatial axis in the scene under observation. Thus, each column of pixels gives a readout of the spectrum for one point or pixel on a line that crosses the scene. The term "pushbroom" arises because in an action reminiscent of a pushbroom sweeping a floor, the field of view is swept through



Modified Offner Spectrometer Optics can be optimized to minimize both spot size as well as spectral and spatial distortions.

the scene, along a line perpendicular to the slit, to acquire spectral readouts from all pixels in the scene.

Accurate calibration is crucial for the extraction of detailed quantitative information from the readouts. The difficulty of calibration is reduced considerably if (1) the monochromatic image of the slit is straight and parallel to the rows of the photodetector array at any wavelength and (2) the spectrum of any point along the slit is straight and parallel to the columns of the array. When these conditions obtain, the length of a monochromatic slit image and the length of the spectrum remain constant across the array. Deviations from these conditions are denoted as spectral and spatial distortion, or "smile" and keystone error.

Although it may seem obvious that the above types of distortions should be minimized, values of as much as 1 or 2 pixels have been accepted in previous spectrometer designs. Recent studies have shown that to preserve the integrity of spectral image data, one must limit smile to no more than a hundredth of a pixel, while similar stringent requirements apply to the keystone error as well as the variation of the pixel spectral response function. These requirements push accuracy and optical-correction requirements into a hitherto unexplored range, where, it turns out, a modified Offner configuration offers design solutions.

In a spectrometer of the classical Offner configuration, there are two concentric mirrors: a concave mirror and a convex mirror with twice the curvature of the concave one. The concave mirror is used twice, as both the primary and the tertiary mirror. A diffraction grating is deposited on the convex mirror. This optical system has a nominal magnification of –1. The system can provide good correction at high f number (ratio of focal length to aperture diameter) and for low-dispersion gratings, while simultaneously limiting smile. But for lower f number and/or larger grating dispersion (which is often needed), it is normally found advantageous to have separate primary and tertiary mirrors (see figure), the curvatures and separations of which can be chosen independently in the design-optimization process.

The design-optimization process includes the use of a merit function based partly on spot size and partly on intersections of specific light rays with the image plane to characterize the centroids of ray distributions as indicators of smile. With that merit function, it has been found possible to control smile and keystone error to essentially arbitrary accuracy at the design stage, over a wide range of designs. These designs all involve centered mirrors with purely spherical surfaces (no aspherical terms), and no tilts. Tolerance analysis has revealed that manufacturability and alignment are within reason.

In controlling distortion and spot size simultaneously, it is important to use the appropriate grating order of diffraction; in particular, the simplest designs are usually obtained by use of the +1 order, for which the angle of diffraction is less than that of the 0 order. Diffraction gratings that would satisfy stringent requirements for low distortion could be fabricated on the convex mirrors by electron-beam lithography. The detailed grating characteristics, including wavelength-dependent apodization and phase errors of multichannel gratings should be understood and controlled, for an actual spectrometer to approximate its design performance. Aberration correction by the grating could also be used to advantage in controlling the performance variation across the field.

This work was done by Pantazis Mouroulis of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access*

the Technical Support Package (TSP) ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

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Refer to NPO-20343, volume and number of this NASA Tech Briefs *issue, and the page number.*

Wide-Angle, Open-Faced Retroreflectors for Optical Metrology

Multiple corner-cube reflectors would be arranged with common vertices.

NASA's Jet Propulsion Laboratory, Pasadena, California

Wide-angle, open-faced retroreflectors of a proposed type would be constructed by use of traditional corner-cube reflectors as building blocks. Wide-angle retroreflectors are needed in optical stellar interferometry, and in other branches of highly precise laser metrology; in particular, two- and three-dimensional triangulation. All of these applications involve the use of reference structures (*e.g.*, optical trusses) and the use of retroreflectors that establish fiducial points on the structures.

Ordinarily, single hollow corner-cube reflectors would be preferred as retroreflectors because they are not wavelength-dispersive and, in principle, return flat wavefronts with no distortion. Unfortunately, the range of useful acceptance angles of a corner-cube reflector in a given plane is only about 60°; this precludes the use of a corner-cube reflector at a fiducial point where two or more optical paths are required to intersect at an angle or angles greater than about 60°. Some non-corner-cube retroreflectors offer wider angular ranges; for

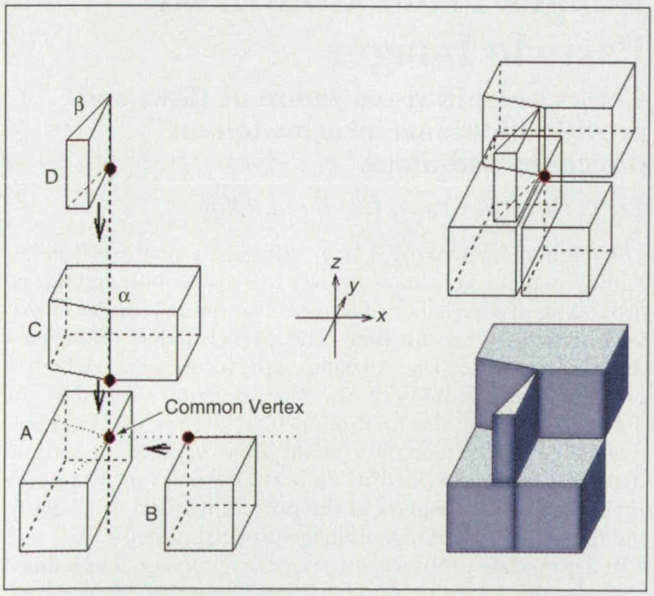


Figure 1. The **Assembly Sequence** uses four prisms in order to form the retroreflector.

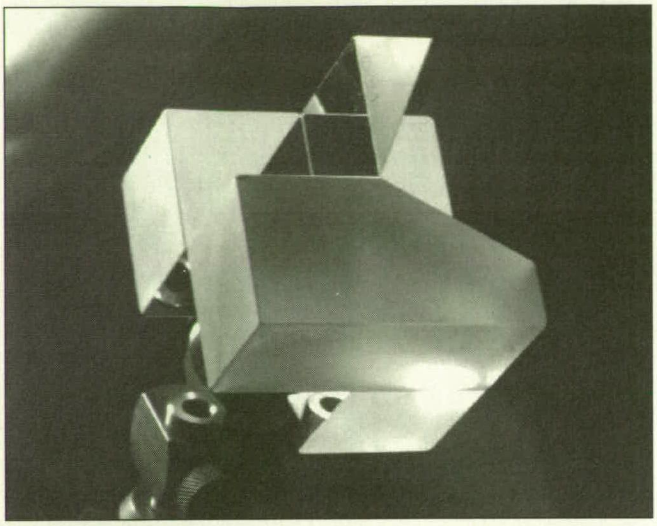


Figure 2. A **Prototype** constructed at JPL is shown in this photograph.

example, a hemispherical lens offers a range as wide as 180°, but the reflected wavefront is subject to spherical and other aberrations, wavelength dispersion, and wavefront distortion associated with thermal expansion of the lens material along the optical path.

The proposed solution is to assemble multiple corner-cube reflectors for each fiducial point, subject to the following requirements: The corner-cube reflectors in the assembly must be mounted in various orientations such that, collectively, they provide acceptance angles to accommodate all optical paths required to intersect at the fiducial point (one or more beams can hit each corner). To establish the single desired fiducial point, the reflectors must be aligned so that their reflective faces intersect at that point.

Different geometries with two, three, even four corners have been considered. For the needs of JPL's space interferometry mission and its testbed, a triple corner cube design has been adopted, with a 30° wedge (see assembly sequence in Figure 1). A prototype has been successfully constructed in mid 1997, validating the concept of such a retroreflector and its manufacturability (see Figure 2).

The corner-cube reflectors would most likely be made from low-thermal-expansion glass prisms. The reflective corner faces would be polished flat to within 1/10 of a typical visible-light wavelength and coated for reflectivity. During assembly of the prisms to form the corners, special multiwavelength interferometric methods would be used to align the reflective faces to within arc seconds of the desired angles.

In practice, the fiducial point would have to be a virtual one, because it would not be possible to assemble multiple corner-cube reflectors with faces that continue, precisely, all the way into a common vertex. To enable assembly, it would be necessary to bevel at least some of the prisms, thereby leaving small gaps at the common vertex. If the bevels were made with custom polishing, then the gaps could be limited to < 50 μm. The quality of the reflected wavefronts would be limited only by the quality of the reflective faces and diffraction from the gaps.

This work was done by Edouard Schmidtlin of **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

Technology Reporting Office
JPL
Mail Stop 122-116
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-2240

Refer to NPO-20174, volume and number of this NASA Tech Briefs *issue, and the page number.*

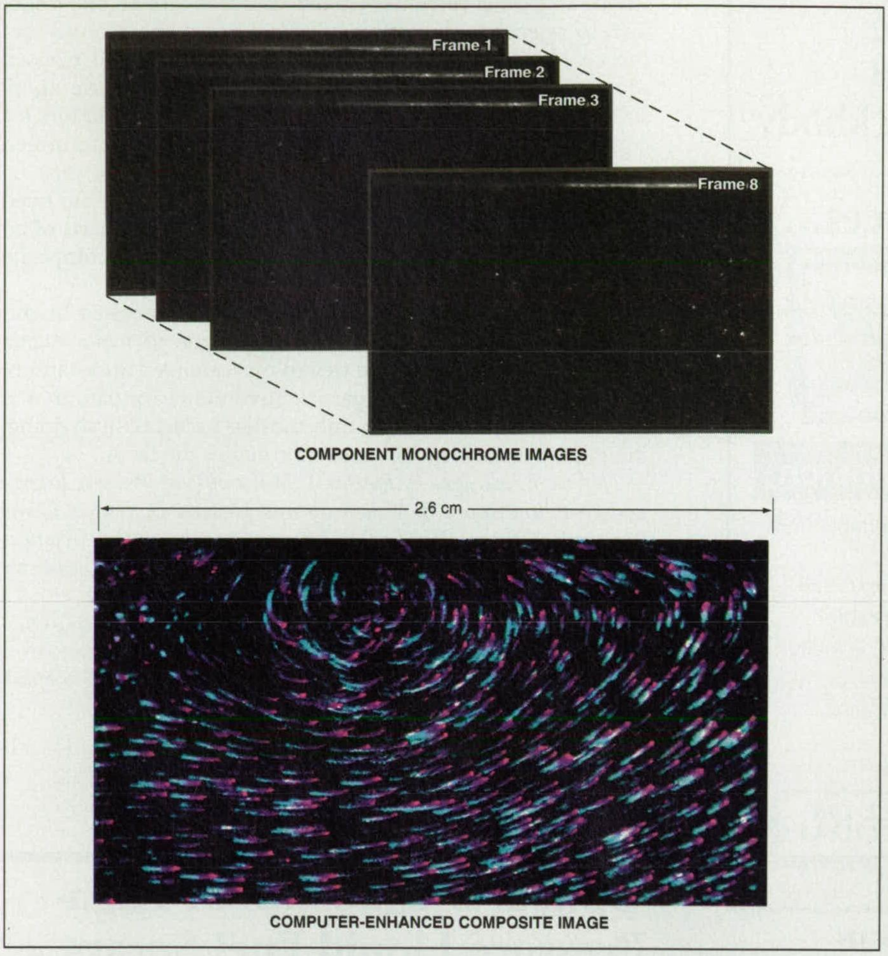
Composing Flow-Streak Images From Colorized Particle Images

Colors assist in visualization of flows and provide additional information on directions and times.

Lewis Research Center, Cleveland, Ohio

A method for making a flow visible in a plane and determining in-plane velocities involves the digitization and digital processing of a sequence of monochrome video images of particles entrained in the flow. The particle-laden flow passes through a sheet of laser or lamp light in the plane, which is oriented perpendicularly to the viewing direction. As described thus far, this method involves the use of techniques that have become common in the flow-visualization art and that have been described in numerous articles in *NASA Tech Briefs*. The unique aspects of the present method originate in the following critical digital image-processing steps:

- In a grey-scale preprocessing stage, each image is enhanced to visually separate the particles from the background. Preprocessing is accomplished by one or more techniques



This **Composite Color Time-Lapse Image** was made from a sequence of eight false-color versions of original video frames that show particles entrained in a flammable liquid that was stirred into a vortex by a flame (not shown) moving to the right across the top. The border of each original frame shows the color assigned to that frame in the composite image. The eight frames were recorded sequentially during a total elapsed time of 0.267 second.

that can include simple semithresholding, percentile semithresholding, and/or a top-hat morphological transformation. The choice of preprocessing technique(s) depends on the quality of the original image.

- A different known false color is assigned to each video frame in the sequence, and the frames are superimposed into a single composite, time-lapse color video image. The information from each frame in the composite image can be distinguished by color from the information from the other frames and thereby identified by color as having been recorded at a unique observation instant in a sequence of observation (video-frame) instants.

The color sequence must be chosen so as not to give rise to aliases in a hue subset. For example, hues of green, yellow, and red could result in a yellow spot for both a particle that was stationary for the full exposure and a particle that just moved through the light sheet during the "yellow" time step. These yellow spots would be indistinguishable. The use of a color sequence from magenta to cyan obviates this "yellow" ambiguity.

In older methods of streak photography and time-lapse imaging, there is no way to determine which way a particle moved along its image streak; there is also no way to determine whether a particle remained in the light sheet during the entire observation time or, alternatively, when it entered and left the light sheet. In the present method, the color of each streak changes from one end to the other in the known sequence, giving a clear indication of the direction of the motion of the particle. If the entire sequence of colors is present in a streak, then the particle can be assumed to have remained within the light sheet during the entire sequence of frames; if any colors are missing, then the times when the particle entered and left the light sheet can be determined from the colors at the ends of its streak image. The missing-color information also provides a qualitative indication of the degree of flow in directions other than in the illuminated plane.

The average in-plane speed of a particle can be computed as the length of its image streak divided by the total elapsed time of the frame sequence. In analyzing

streaks to extract velocities (speeds and directions), one might wish to reject streaks with missing colors on the ground that the corresponding particles did not spend the full elapsed time in the light sheet. Optionally, one could use these streaks, provided that the times used in the denominators for computing speeds are the partial elapsed times determined from the missing colors.

Unlike in conventional streak photography, there is no need for *a priori* knowledge of exposure times. Different parts of an image can be processed differently, if necessary. A composite exposure time can be chosen after a test.

By use of a digital frame recorder, images processed by this method can be rerecorded onto video tape to make digital movie sequences that can be viewed on computer workstations. These movies show moving particle streamlines (or pathlines in unsteady flows), rather than only moving particles; in so doing, the movies make it much easier to visualize the flows.

This work was done by Fletcher J. Miller of Case Western Reserve University and Mary B. Vickerman and Howard D. Ross of **Lewis Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135.

Refer to LEW-16381.

Optical Diagnostics of High-Pressure Liquid Fuel Sprays

Lewis Research Center, Cleveland, Ohio

A report describes experiments in which nonintrusive optical diagnostic techniques were applied to high-pressure fuel sprays in simulated advanced turbine-engine combustor environments. The experiments involved three different fuel injectors in two unique optically accessible combustors: a radially-staged gas turbine combustor designed for testing multiple injectors and a flame tube designed for testing single injectors. Flows were observed at inlet temperatures from 533 to 810 K, inlet pressures from 0.55 to 1.7 MPa, and various mass flow rates. Planar laser-induced fluorescence and planar Mie scattering were used to image distributions of sprayed fuel, while phase Doppler particle analysis was performed to determine size and velocity distributions of fuel droplets. Analysis of the data thus acquired lead to the conclusions that (1) differences among spray patterns for different fuel injectors and operating conditions are readily observable and (2) fuel-spray angles can easily be measured under realistic conditions. This work clearly demonstrates utility of these nonintrusive optical techniques for investigating fuel-spray patterns in realistic turbine-engine combustor environments.

This work was done by R. J. Locke of NYMA, Inc., and Y. R. Hicks, R. C. Anderson, and M. M. Zaller of **Lewis Research Center**. *To obtain a copy of the report, "Fuel Injector Patternation Evaluation in Advanced Liquid-Fueled, High-Pressure, Gas Turbine Combustors, Using Nonintrusive Optical Diagnostic Techniques," access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135.

Refer to LEW-16701.

INDUSTRY LEADERS

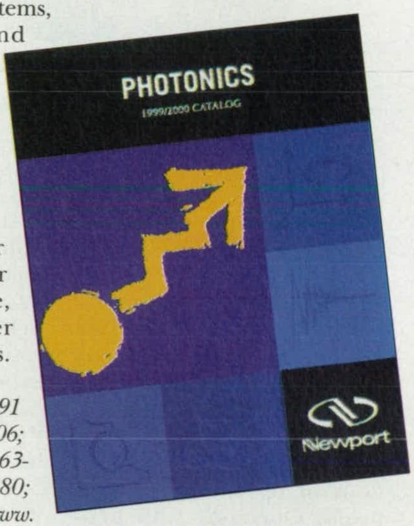
Profiles Of Pathsetting Companies Serving The Engineering Field

NEWPORT CORP.

Newport's 1999/2000 Photonics Catalog features more new products than ever before and several new product categories, all captured in its 350 pages.

Our selection of products targeting the fiber optic telecommunications market includes:

- Benchtop and rack-mountable, single-channel, and modular laser diode controllers and mounts, designed for handling butterfly DFB and pump laser diodes;
- Fiber optic instrumentation, including our new modular Photonics Test System, featuring dozens of instrumentation plug-in modules, which can be used for testing of fiber optic components; our new wavelength reference and stabilized light sources used in DWDM applications; and our fiber optic amplifier family;
- Handheld and benchtop optical power meters, including optical detectors and calibrated integrating-sphere systems;
- A full line of high-speed detectors, operating up to OC-192 data rates (10 Gb/s);
- A complete selection of fiber optic components, including isolators, circulators, couplers, WDMs, polarization controllers, and optical fibers, available with various connector styles;
- Tunable laser diode sources for testing of fiber optic components;
- Automated laser diode packaging and test systems, using laser welding and epoxy-based processes, and automated waveguide bonding stations, used for aligning and attaching fiber arrays to waveguide-based WDM components.



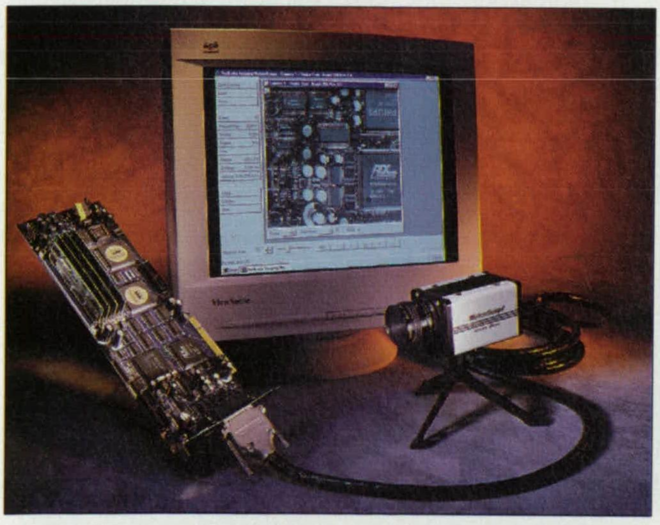
A multitude of other products are offered for high-power laser diode, spectroscopy, and fiber optic sensor applications.

Newport Corporation, 1791 Deere Ave., Irvine, CA 92606; (800) 222-6440; (949) 863-3144; fax: (949) 253-1680; sales@newport.com;http://www.newport.com/lit99

Circle No. 774

REDLAKE IMAGING

Redlake Imaging is the manufacturer of the *Motion*Scope® high-speed imaging product lines. The *Motion*Scope series is based on the premise that high-speed imaging for motion analysis should be affordable, small, and easy to use.



*Motion*Scope models range from stand-alone systems and PC peripherals to network-based cameras that record up to 8000 images per second (shutter up to 10 microseconds).

The *Motion*Scope PCI series is a plug-and-play PC peripheral for capturing high-speed digital images directly into a PC. With the "point & click" Windows-based application software, the PCI series gives you more motion analysis capabilities in a full digital environment. Images are easily archived in the Microsoft .AVI file format, extending the functionality of the system by interfacing to many third-party analysis software packages.

The e/Cam series is a network-based (Ethernet) high-speed digital imaging system for motion analysis applications that require many cameras to be controlled by a PC. Designed for motion analysis applications such as research & development, automotive crash testing, and military and aerospace research, these capabilities makes the *Motion*Scope the ideal tool. *Motion*Scope PCI board-level products are also available for OEM and integrator applications that require high-speed continuous image acquisition.

Redlake Imaging Corporation, 18450 Technology Drive, Suite A, Morgan Hill, CA 95037; (408) 779-6464; (800) 453-1223; fax: (408) 778-6256; e-mail: sales@redlake.com

Circle No. 778

OPTOSIGMA CORP.

OptoSigma offers more than 3500 off-the-shelf optics and high-performance optical coatings. All optics and coatings are designed and manufactured to extremely tight specifications and tolerances for the highest-performance off-the-shelf solutions.

Catalog optics include high-power laser and broadband mirrors; beamsplitters; windows; spherical and achromatic lenses; micro-optics; prisms; polarizers; and filters. Sizes range from 2 mm to over 6 inches in diameter. Lens focal lengths vary from several to thousands of millimeters. Lenses are available in BK-7 or fused silica with antireflection coatings for broadband, laser-line, or super-low-loss applications.

OptoSigma's coating factory in Santa Ana, CA, is automated to ensure highly repeatable coatings. This capability provides the consistent run-to-run performance required by most OEM applications. In addition, use of ion-assisted deposition in our coating process ensures more densely packed thin-film coatings that are extremely durable and capable of withstanding very high laser fluence.

OptoSigma's metrology laboratory is sophisticated and complete, thus ensuring that your specifications are met every time. Computer-controlled spectral and interferometric instrumentation allows us to provide optical performance data to you in several convenient electronic or paper formats.

For more information ask for OptoSigma's product catalog.

OptoSigma Corporation, 2001 Deere Avenue, Santa Ana, CA 92705; (949) 851-5881; fax: (949) 851-5058; e-mail: optosigm@ix.netcom.com; www.optosigma.com

Circle No. 772

SPIRICON INC.

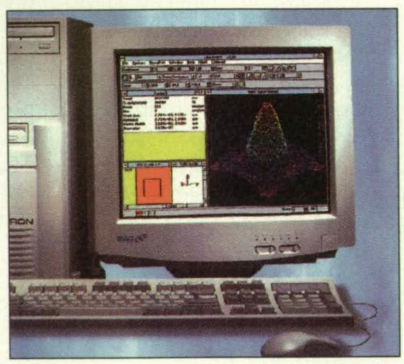
Spiricon announces the release of its latest PC Laser Beam Analyzer. The version 2.60 incorporates a number of features for enhanced performance. With the release of version 2.60, 10-bit and 12-bit intensity resolution of the profile of your laser beam is now possible with spatial resolutions of up to 1024 × 1024 pixels. Operating with high-dynamic-range digital cameras, the LBA-PC products now provide the highest obtainable performance in a PC-based laser beam analyzer system. Also included in this release is the ability to export files compatible for importation into Frequency Resolved Optical Gating (FROG) software. As well, a 2-point far-field divergence method, a column and row summation export file, and capability to copy images and results to the Windows clipboard have been added.

This version runs on Windows 95, Windows 98, and Windows NT. These 32-bit-mode operating systems significantly speed up the beam profile viewing and analysis. This instrument's capability for remote-control operation using LabView GPIB interfaces enables many new automated testing applications.

The most important feature of the LBA-PC is the patented Ultracal. This is an automatic calibration technique which sets the baseline of the camera precisely at zero, and saves negative numbers to enhance the accuracy of the dimensional analysis of laser beams. This feature distinguishes the LBA-PC as the camera system able to make exact second-moment beam-width measurements, which are the new ISO standard.

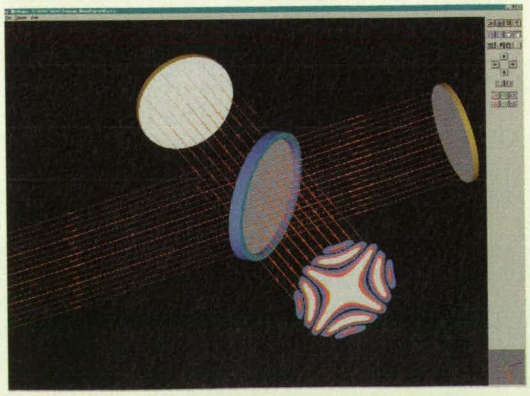
Spiricon Inc., 2600 North Main, Logan, UT 84341; (435) 753-3729; fax: (435) 753-5231; e-mail: sales@spiricon.com

Circle No. 769



BREAULT RESEARCH ORGANIZATION (BRO)

New ASAP 6.5 from Breault Research Organization (BRO) will be released in March 1999. ASAP is an optical modeling tool for the design, analysis, and prototyping of optical systems. ASAP combines 3D surface and structure modeling techniques with very flexible ray tracing, and both coherent and incoherent beam propagation algorithms. It is the only commercially available optics program that combines geometrical and physical optics with full 3D models of optical and mechanical systems. ASAP 6.5 has dozens of improvements for increased efficiency, accuracy, and usability.



In conjunction with ASAP 6.5, the new Exterior Lighting Test Module (ELTM) is being released. Used with ASAP, ELTM facilitates the process of testing automotive exterior lighting. It analyzes and tests illumination patterns of reflector and bulb geometries for determining compliance with government requirements.

In addition to optical software, BRO offers engineering services, hardware, and training. BRO's engineering department will supplement clients' existing resources or serve as the primary engineering team. The BRO team brings experience in all aspects of optical and illumination system design, simulation, performance analysis, tolerance specification, prototyping, and support through testing. Hardware capabilities allow BRO to take projects beyond theoretical design and into the marketplace.

Breault Research Organization, 6400 East Grant Rd., Suite 350, Tucson, AZ 85715; (800) 882-5085 or (520)721-0500; e-mail: info@breault.com; www.breault.com

Circle No. 750

MELLES GRIOT

Melles Griot diode-pumped solid-state (DPSS) lasers deliver low-noise 532-nm output, with excellent power and mode stability. They are completely self-contained, and come in two package configurations, with output power ranging from 5 mW to 40 mW. Both product families are CDRH, IEC-825 and CE compliant.

The 58 GMS series is designed for OEM use and operates from 5-V DC input power. With optical noise of less than 0.5 % rms and a stable, diffraction-limited green beam, it is an ideal source for reprographics, laser-induced fluorescence, medical diagnostics, and other OEM applications. The compact, rugged housing contains all the drive electronics, and is easily integrated into new or existing designs.

The 58 GIL series is designed for alignment applications in harsh environmental conditions such as those found in sawmills, textile processing, or sheet-metal fabricating facilities. The laser operates from 100-V AC to 230-V AC, and its cylindrical package configuration allows for operation to 40°C without additional user-supplied heat sinking. Optional line-generating optics are available to provide either Gaussian or uniform-intensity lines.

Custom versions are available to meet specific OEM requirements. Melles Griot also manufactures infrared and red laser systems with identical package configurations that can be directly interchanged with these green systems.

Melles Griot Electro-Optics and Instruments, 4601 Nautilus Court South, Boulder, CO 80301; (800) 326-4643; (303) 581-0337; fax; (303) 581-0960; e-mail: 103244.1666@compuserve.com

Circle No. 781

CVI LASER CORPORATION

CVI Laser offers low-loss, prismless chirp compensation for femtosecond laser systems. Peak correction is -100fsec^2/bounce. Compensation is available at any center wavelength from 450-2000 nm.

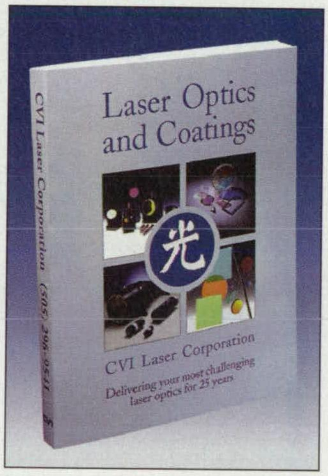
Next-generation Ti:sapphire and other femtosecond laser systems need prismless compensation of the built-in positive chirp encountered in the laser optical system. This becomes mandatory in industrial and biomedical applications where the laser must provide a compact, stable, and tweak-free solution for the end user. Researchers have also asked for an additional knob to control and optimize the pulse performance in experimental systems.

Now CVI meets these needs with off-the-shelf TNM2 Series negative group delay dispersion (GDD) mirrors. High manufacturing yields using CVI's proven processes move negative GDD mirror capability from the optics journals to your application at affordable prices. Available immediately on standard 012.7- and 025.4-mm substrates, TNM2 mirrors can be employed both intra- and extracavity to satisfy chirp control requirements.

In preliminary experiments, 200-mW 80-fsec pulses centered at 785 nm were achieved in a simple prismless Ti:sapphire oscillator. The excellent agreement between theory and the white-light interferometer measurement of the mirror's higher-order phase properties, coupled with a highly manufacturable design, led to the product release of the TNM2 Series. Contact your CVI sales representative for more information.

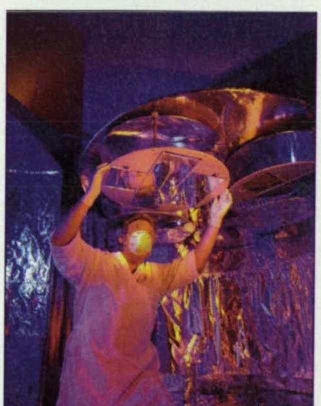
CVI Laser Corporation, 200 Dorado Place S.E., Albuquerque, NM 87123; (505) 296-9541; fax: (505) 298-9908; www.cvilaser.com

Circle No. 779



ZC&R COATINGS

ZC&R offers a complete line of high-quality precision coatings for optical and thermal applications. Standard and custom applications include high-power laser, antireflection, beamsplitter, hot and cold mirror, bandpass, metallic, polarizer, fluorescence, and covert coatings.



We offer our high-output ion-assisted deposition (IAD) process to deposit thin-film optical coatings on temperature-sensitive substrates such as plastics, cemented optics, and fiber optics.

Specialty coatings include our new DuraCoat-Z antireflection coating, designed for use on surfaces exposed to harsh elements or frequent handling. IAD processing creates a resistance to scratches, fungus, and chemicals, and provides excellent environmental stability. It withstands more than 200 rubs using the eraser test per MIL-STD-810. Average transmission is <0.6 percent, 425-675 nm, at normal incidence.

ZC&R provides a wide variety of coatings for display applications. Our IAD index-matched ITO coatings allow precision control of resistivity and can be index-matched to virtually any medium including liquid crystal and polyimide. We also provide night vision (NVIS) filters for security and military display applications. Both coatings can be customized to meet unique specifications.

New state-of-the-art custom-designed facilities include 32- and 64-in. vacuum chambers for production of coatings up to 24 in. in diameter, in quantities from prototype to OEM volumes. ZC&R meets MIL-C-675, MIL-M-13508, and MIL-C-48497 specifications.

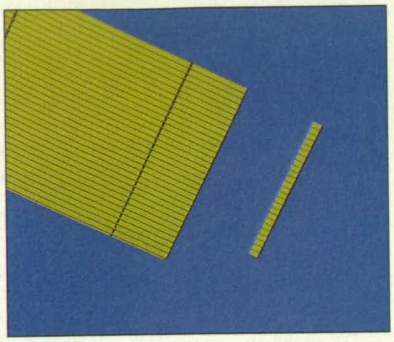
ZC&R Coatings, 1401 Abalone Ave., Torrance, CA 90501; (310) 381-3060; (800) 426-2864; fax: (310) 782-9951; e-mail: info@zcrcoatings.com; www.zcrcoatings.com

Circle No. 780

As seen at Photonics West

NEW PRODUCTS

PRODUCT OF THE MONTH



High-Power Laser Diode Bars

Siemens Microelectronics, Cupertino, CA, introduces a line of stackable high-power laser diode bars that the company says can deliver up to twice as much power per bar with the same lifetime and cost efficiency as lower-powered diode designs. The bars come in five types: the SPL BW81 offers power from 10-20 W at a wavelength of 808 nm; the SPL BG81 (808 nm) and SPL BG94 (940 nm) operate between 40-50 W, and the SPL BS81 (808 nm) and SPL BS94 (940 nm) operate between 60-100 W quasi-continuous wave. At 40-W operation at these wavelengths, lifetime test have yielded MTTFs greater than 30,000 hours. Pricing starts at $270 per bar for 40-W bars in quantities of 100.

For More Information Circle No. 756

Optical Fused Silica

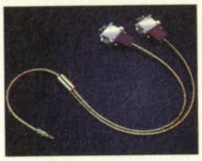
Schott Glass Technologies, Duryea, PA, introduces synthetic fused silica, available in three optical-quality grades, and produced from $SiCl_4$ by flame pyrolysis, rendering it bubble- and inclusion-free. Schott says the product is characterized by excellent transmission in the ultraviolet and visible spectral ranges, and that it also exhibits excellent UV-excimer laser-damage resistance at 248 and 193 nm. It is available in diameters up to 300 mm. Depending on the quality level, Schott can supply pieces with weights up to 10-30 kg.

For More Information Circle No. 761

Spectrometers for Laser and LED Test

SensorPhysics Inc., Oldsmar, FL, makes available the LaserWave series, a new line of spectrometers for laser and LED measurement. The series, which the company characterizes as low-cost PC-based instruments, covers the spectral range of 200-1600 nm. The LaserWave-I is optimized for 750-1050 nm; a wider-range instrument, covering 400-1000 nm, can be integrated with the company's LaserTest beam profiler for simultaneous measurement of the wavelength and spatial beam profile. This version can also be integrated with microscopes such as the company's LambdaScope.

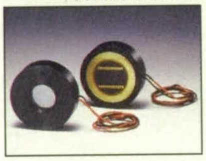
For More Information Circle No. 758



High-Power Laser Diode at 1.8 μm

Opto Power Corp., Tucson, AZ, announces what it calls the first commercially available high-power monolithic laser diode array at 1.8 μm. Among packaging configurations are a single-array device that delivers 7 W of continuous-wave output, a fiber-coupled version that provides 3.5 W from an optical fiber with a 520-μm diameter and an 0.22 numerical aperture, and a stack with 100 W of output. Other conductively cooled single-array, stacked-array, and fiber-coupled-array configurations over the wavelength range 1.75-1.87 μm are available upon request. Accessories include transient-protected drivers/power supplies and active air-cooled or water-cooled heatsinks for thermal management.

For More Information Circle No. 759



Electron Bombardment CCD

The N7640 electron bombardment CCD tube (EB-CCD) from Hamamatsu Corp., Bridgewater, NJ, is designed to provide high gain and signal-to-noise performance in scientific and industrial low-light-level imaging and in biological fluorescence/luminescence imaging. The 2/3-in. proximity-focusing device has a multialkali photocathode, providing rapid readout for 30-fps video-rate operation. At an applied voltage of -6 kV, gain is typically 220 with resolution of 400 TV lines, and at -8 kV gain is 600 at 330 TV lines. Dark current is 80 e/pixel and full-well capacity is 65,000 electrons. Price in OEM quantities is $101.

For More Information Circle No. 760

Sapphire Optics

The Ultrasound and Optics Division of ValpeyFisher, Hopkinton, MA, says its wide variety of sapphire optics covers the UV to the IR with very high transmission. The company can either chemically or optically polish to meet specifications for flatness and surface quality, achieving parallelism down to 1.0 arc second. ValpeyFisher says its sapphire offers excellent physical characteristics and can withstand high temperatures and most chemicals.

For More Information Circle No. 757

4-W Fiber Array Packaged Systems

Coherent Semiconductor Group, Santa Clara, CA, offers 4-W fiber array packaged (FAP) bars and systems. These couple to an 800-μm fiber with a numerical aperture of <0.16. The company says the FAP offers increasing levels of thermal management integration and is especially easy to integrate into existing applications that make use of fiber-delivered laser diode emission. A complete turnkey solution, the FAP system is ideal for medical therapeutic processes, as well as for the pumping of a variety of solid-state media, according to Coherent.

For More Information Circle No 762

PC Laser Beam Analyzer

The Version 2.60 of the Model LBA-500PC laser beam analyzer from Spiricon, Logan, UT, makes possible 10- and 12-bit intensity resolution of the beam profile, and spatial resolutions of up to 1024 × 1024 pixels. This version also has the capability to export files into frequency-resolved optical gating software. Spiricon says that the patented Ultracal, an automatic calibration technique that sets the camera baseline precisely at zero, saving negative numbers to enhance accuracy of beams' dimensional analysis, distinguishes the LBA-500PC as the system able to make exact second-moment beam-width measurements, the new ISO standard.

For More Information Circle No. 763

Noncontact Optical Profiler

Burleigh Instruments Inc., Fishers, NY, says its Horizon™ noncontact optical profiler gives users the ability to image nondestructively both smooth and rough surfaces with an X-Y scan range up to 1.75 mm and a Z range up to 100 microns, while providing vertical resolution on the angstrom scale. An interactive CD-ROM training program guides the operator from setup through image acquisition. Other features include two modes of operation—smooth for samples with Z values less than 1.2 microns and texture mode for rough or discontinuous samples with Z values above that—and an industry-standard Windows interface identical to Burleigh's VISTA SPM.

For More Information Circle No. 764

Diode-Pumped Solid-State Lasers

Spectra-Physics Lasers Inc., Mountain View, CA, releases the Millennia® *s* series, which its says offers the industry's smallest package for a high-power diode-pumped solid-state laser with a range of output levels from 2-10 W. According to the company, the series' monolithic architecture and advanced thermal design provide unprecedented power stability and beam pointing with a minimal footprint and no bulky heatsink. The series has a patented intracavity doubling process (QMAD) for optical noise of less than 0.05 percent. It requires only 110- or 220-V single-phase power and offers RS-232 port control or optional digital remote operation.

For More Information Circle No. 765

Things Moving too Fast for You?

*Motion*Scope® PCI Can Help You.

Redlake Imaging Corporation offers a family of affordable high-speed computer based digital imaging products designed to meet your motion analysis needs.

- Up to 8,000 Digital Frames per Second
- Plug & Play PC Peripheral
- Easy to Use "Point & Click" Application Software
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E-Mail: sales@redlake.com

REDLAKE IMAGING

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REDLAKE IMAGING
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Vol. 23, No. 3 March 1999 This form expires: June 30, 1999

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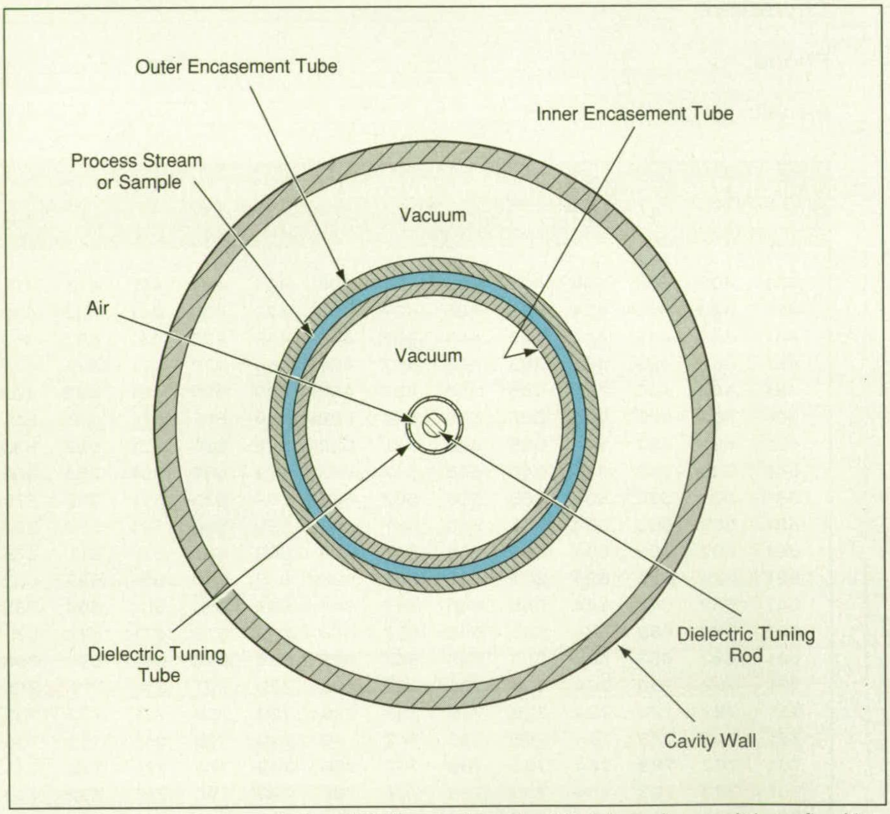
Microwave Heating With Uniform Temperature History

All parts of a process stream or a stationary sample are processed equally.

NASA's Jet Propulsion Laboratory, Pasadena, California

Several microwave-cavity devices at various stages of development are designed for heating material samples or process streams with uniform temperature-versus-time histories. These devices could satisfy needs for heating according to well-regulated temperature-vs.-time schedules for batch and stream processing in diverse applications; for example, pharmaceutical processing, extrusion and molding of plastics, and processing of biological or medical samples.

The figure presents a simplified axial cross-sectional view of one such device for heating either (1) a stationary annular or cylindrical sample of material or (2) a process stream flowing axially, with azimuthal uniformity, in a narrow space between an inner and an outer encasement tube. The geometry of the device is chosen so that in the plane of the figure or any other plane along the cylindrical axis, the process stream or sample is exposed to substantially equal microwave power density at all points along its circumference.



The **Sample or Process Stream Is Heated Uniformly** throughout its interior because it is confined in a narrow annular region that contains an antinode of an axisymmetric TM_{010} electromagnetic mode of the microwave cavity, which has no axial dependence.

The microwave cavity is dimensioned to support an axisymmetric mode, and the radii of the inner and outer encasement tubes are chosen so that the annular sample or flow space between these tubes contains an antinode of either the electric or the magnetic field. This choice of dimensions minimizes the spatial variation of the electric or magnetic field within the sample, thereby minimizing spatial variations in the heating rate. The encasement tubes should be made of a low-loss dielectric material; for example, quartz.

If the sample or process stream is of a lossy dielectric material (e.g., a plastic), then for maximum and substantially uniform heating, the annular space should be dimensioned to contain an antinode of the electric field. Similarly, if the material in question is subject to heating predominantly by the magnetic field, then the annulus should be dimensioned to contain an antinode of the magnetic field.

To prevent convective cooling of the heated sample or process stream, the empty spaces within the microwave cavity are evacuated. To minimize radiative cooling, the cavity wall and end plates are coated with gold, which is highly reflective of thermal radiation. The innermost part of the cavity is occupied by a fixed dielectric tube and an axially movable dielectric rod within the tube; these components are used to tune the cavity to resonance at the frequency of a magnetron or other source that supplies the microwave power. [Tuning by use of this technique was described in "Improved Tuning of a Microwave Cavity for Heating Samples" (NPO-20409), *NASA Tech Briefs*, Vol. 22, No. 11 (November 1998), page 54.] In the case of a process flow, the tuning rod and tube can be tapered to compensate for the variation of the permittivity of the material with temperature and thus with axial position, to keep the desired field antinode within the annulus at all axial positions.

This work was done by Henry W. Jackson of Acro Service Corp. and Martin Barmatz of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

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Refer to NPO-20459, volume and number of this NASA Tech Briefs *issue, and the page number.*

Algorithm for Equalizing Rectangular Signal Constellations

For rectangular constellations, performance exceeds that of an older algorithm.

NASA's Jet Propulsion Laboratory, Pasadena, California

A rectangular-constellation-based blind-equalization (RECBEQ) technique implemented by a real-time, recursive algorithm has been developed to improve the performances of radio receivers in recovering unknown signals that are modulated with digital information and that have been distorted in propagation by multipath channels and carrier offsets. The technique is so named because it is intended specifically to enable the equalization of large-order rectangular signal constellations; for example, that of quadrature amplitude modulation (QAM).

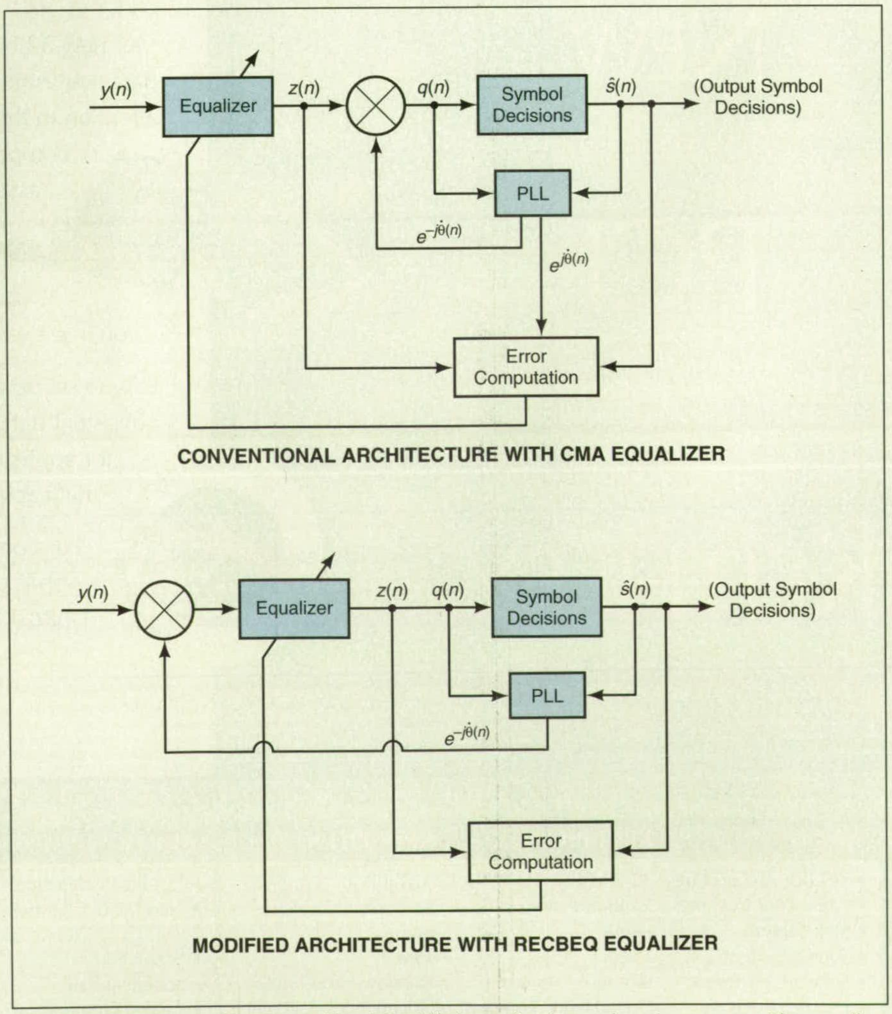
Blind equalization provides for the recovery of unknown signals via a finite-dimensional linear projection of a channel output data vector; namely,

$$z_n = \sum_{i=0}^{L-1} w_i y_{n-i}$$

where z_n is the complex output sample from the blind equalizer at the nth sampling interval, w_i is the ith of L blind-equalizer coefficients, and y_j is the jth complex sample from the unknown channel. The latter sample can be expressed as a convolution of the sampled channel impulse response f_k with an unknown sequence of independent and identically distributed source symbols a_i; that is,

$$y_j = \sum_k f_k a_{j-k}$$

This equalization process is said to be "blind" because the w_is are derived



These **Two Receiver Architectures** effect joint blind equalization and carrier recovery. The equalizer and the PLL are connected in different ways in the conventional receiver architecture based on the CMA and the modified receiver architecture based on the RECBEQ algorithm.

from available channel output data only, without knowledge of either the transmitted signal waveform or the linear channel.

The present blind-equalization technique belongs to a class of such techniques in which the w_ks are chosen to maximize or minimize objective functions (e.g., cost functions). The objective function for this technique is derived from a uniformly most powerful (UMP) scale-invariant hypothesis test between factored (rectangular) generalized Gaussian distributions. The net result of the derivation is the following time-recursive equation for updating the blind-equalizer coefficients:

$$w_k(n+1) = w_k(n) - \beta_{\text{rect}}\left\{\left(|z_{xn}|^{s-2} z_{xn} + j|z_{yn}|^{s-2} z_{yn}\right) - R_{\text{Orect}} z_n\right\} y_{n-k}^*$$

where β_{rect} is a positive "step size" which controls the rate of adaptation (smaller values of β_{rect} result in lower adaptation rates); the subscripts x and y denote the real and imaginary parts, respectively, of the affected quantities; s is a positive constant, greater than 2, which helps determine the steady-state performance of the equalizer (larger values of s yield lower steady-state adaptation noise but result in greater implementation complexity and greater sensitivity to additive receiver noise — it has been observed that $s = 8$ provides a good tradeoff between algorithm adaptation noise in steady state and sensitivity to additive receiver noise); R_{Orect} is a positive constant which controls the scale of the equalized constellation at convergence and is given by:

$$R_{\text{Orect}} = 2E|a_x|^s / E|a|^2$$

and $E()$ is the expectation operator. The equation for $w_k(n+1)$ converges rapidly for input rectangular constellations distorted by multipath.

When residual carrier offsets are present, the receiver must also include a data-directed phase-locked loop (PLL). Part of the figure depicts a conventional receiver architecture that incorporates a data PLL along with an older blind equalizer of a type called "CMA" (constant-modulus algorithm). The equalizer output is phase-corrected ("derotated") by the PLL output, which is driven by symbol decisions based on the phase-corrected equalizer output. This architecture is viable because the CMA is not affected by phase rotations of the input signal constellation, and therefore phase correction can occur downstream from the CMA equalizer.

Unlike the CMA, the RECBEQ algorithm is sensitive to the phase orientation. Extensive tests have revealed that the RECBEQ algorithm can acquire a rotating rectangular constellation, but not at the same level of precision that would be achieved if the constellation were static. This finding led to the development of the modified architecture, also shown in the figure. Here, the input to the RECBEQ equalizer is phase-corrected by the PLL output, which again, is driven by symbol decisions based directly on the equalizer output. In this architecture, the RECBEQ initially equalizes the rotating constellation to such an extent that the PLL can lock up and finalize the joint equalization/carrier-recovery process.

Results of computational tests show that for rectangular constellations, the RECBEQ algorithm converges much more quickly, to lower-noise solutions, than does the CMA. For other, more-rounded constellations [e.g., those of *M*-ary-phase-shift keying (MPSK)], the CMA performs better. Computationally, both algorithms are comparable.

This work was done by Edgar Satorius of Caltech and James Mulligan of TASC for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category. NPO-20324*

For More Information Circle No. 416

Graphics Performance

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industry for performance
The new C360 with *fx*6
graphics lets you "fly
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Value for Money

The C360 typically delivers 30-40% more MCAD performance than HP's earlier award winning C240 workstations for a lower price. A real performance and productivity advantage.

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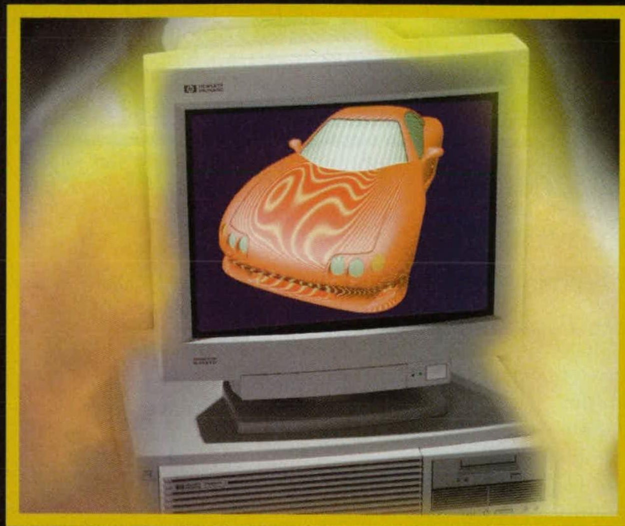
Award-Winning Technology

Performance Computing Magazine recently gave their Workstation of the Year award for 1998 to HP's C240 workstation. Now HP underlines its commitment to maintaining the lead in performance workstations by delivering the C240's natural successor – th

Image courtesy of ICEM Technologies

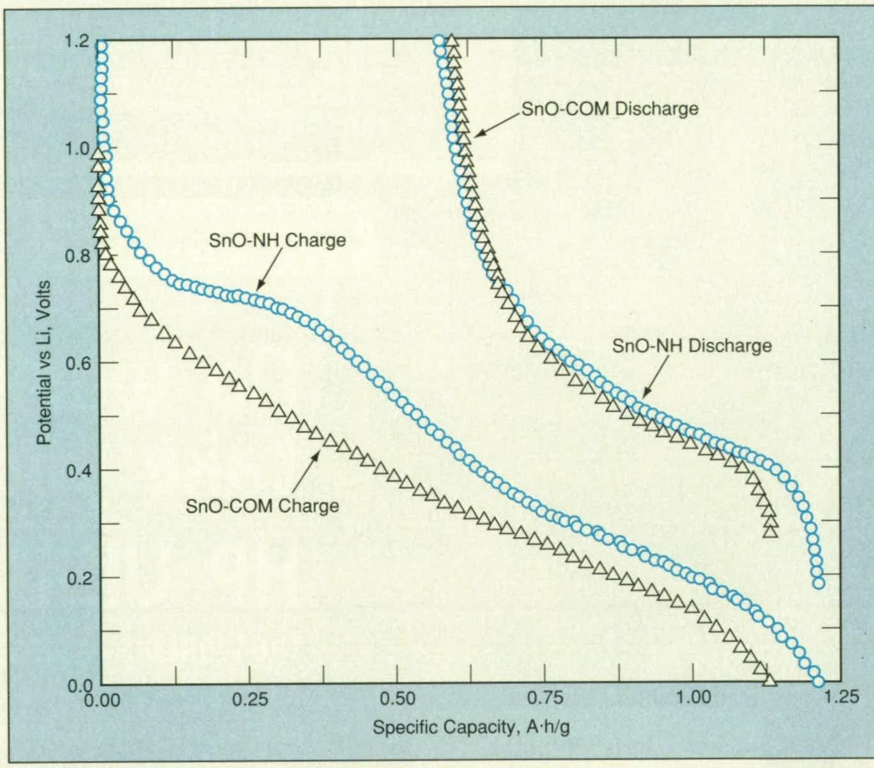


Improved Synthesis of SnO Powder for Lithium-Ion Power Cells

This powder gives better electrochemical performance and costs less.

NASA's Jet Propulsion Laboratory, Pasadena, California

An improved method of synthesis of crystalline tin monoxide (SnO) powder for use in anodes of lithium-ion electrochemical power cells has been developed. The carbon used in anodes of Li-ion cells is relatively expensive and difficult to produce, and SnO has been found potentially useful as an alternative anode material. One major disadvantage of the method heretofore followed in producing commercial crystalline SnO powder is that it involves heating. The improved method does not involve heating and thus offers the potential to reduce the cost, time, consumption of energy, and risk of contamination in the production of crystalline SnO powder. Fortuitously, it turns out that the improved method also yields powder with greater specific surface area, making it possible to fabricate electrodes with reversible charge/discharge capacities, for a fixed rate, greater than those of electrodes made from commercial crystalline SnO powder.



These **Titration Curves** from charging and discharging of Li/SnO half cells have been interpreted as signifying that the initial reversible capacity of the electrode made with SnO-NH was about 20 percent greater than that of the electrode made with SnO-COM.

In the commercial method, synthesis begins with the dissolution of metal-ion-containing salt in distilled water. The resulting solution is added dropwise into a basic (e.g., NaOH) solution, where, typically, particles of amorphous metal hydroxide precipitate. The precipitate particles are washed, filtered, and dried in air. Next, the precipitate particles are heated in a crucible in air to a temperature typically above 200 °C to transform them from amorphous metal hydroxide to crystalline tin monoxide.

The improved method is derived from the commercial method but differs in key respects. Instead of starting by completely dissolving metal-ion-containing salt, one starts with an insoluble combination of $SnCl_2$ in water to form $Sn_xO_yH_z$ compounds. The tin-bearing solution obtained by hydrolysis in the improved method is acidic. The tin-bearing acidic solution is added dropwise to a basic solution (NaOH or NH_4OH). However, whereas the pH of the basic solution is allowed to fall to about 10 or 11 as the acidic solution is added dropwise in the commercial method, the pH is not allowed to fall in the improved method; instead, NaOH is added continuously to maintain the pH of the basic solution at 14 during the dropwise addition of the acidic tin-bearing solution. A white gel precipitate is formed and, after about 45 minutes, becomes transformed into a black precipitate comprising aggregated crystalline SnO powder. The precipitate is washed, filtered, and dried as in the commercial method, but unlike in the commercial method, no further processing (that is, no heating) is needed.

The electrochemical performance of crystalline SnO powder synthesized by the commercial method (SnO-COM) and of SnO powder synthesized by the improved method with no heating (SnO-NH) were measured during charging and discharging of half cells. Each half cell included a nickel-mesh-supported lithium foil that served as both an anode and a reference electrode, plus a cathode fabricated by spraying a mixture of SnO powder, a poly(vinylidene fluoride) binder, and carbon black onto a copper foil substrate. The electrodes in each cell were separated by 50-µm-thick poly-propylene membranes. The cells were filled with an electrolyte mixture of $LiPF_6$, ethylene carbonate, and dimethyl carbonate.

The figure presents titration curves from charging and discharging of the half cells between a charge cutoff potential of 1.2 V and a discharge cutoff potential of 0 V. These curves indicate a greater specific charge capacity for the SnO-NH electrode than for the SnO-COM electrode. The increase in specific capacity can be attributed to greater specific surface area (0.871

m^2/g for SnO-NH vs. 0.297 m^2/g for SnO-COM). This effect increases the accessible electrode surface area and ease of incorporation and extraction of Li ions.

This work was done by Chen-Kuo Huang and Subbarao Surampudi of Caltech and Jeffrey Sakamoto and Jeffrey Wolfenstine of UC Irvine for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category.*
NPO-20355

Diffusing Hf and Si Into Aluminide Bond Coats for TBCs

Turbines could be operated at higher temperatures.

Lewis Research Center, Cleveland, Ohio

A process for making superior diffusion platinum-aluminide bond coats for plasma-sprayed or physical-vapor-deposited thermal-barrier coats (TBCs) on superalloy substrates has been devised. The novel aspect of the process lies in the use of several relatively inexpensive pack diffusion steps to incorporate hafnium and silicon to increase resistance to oxidation.

TBCs are typically composed of yttria-stabilized zirconia and are typically used to protect superalloy turbine-engine components against high temperatures. A bond coat provides both mechanical and chemical bonding between the underlying superalloy and the overlying TBC. Diffusion-type aluminide bond coats offer advantages (including lower cost) over conventional MCrAlY (where "M" denotes Fe or Ni) bond coats, except that the diffusion-type aluminide coats exhibit lower resistance to oxidation. Any change in material or processing that increases the ability of bond coats to resist oxidation also increases the durability of TBC coats.

The incorporation of Pt into a diffusion-type aluminide bond coat increases its resistance to oxidation. Prior to the development of the present process, Hf and Si had been incorporated into MCrAlY bond coats to increase resistance to oxidation, but had not been incorporated into diffusion Pt-aluminides.

The basic version of the present process comprises the following steps:

1. A hafnided surface layer with a thickness between 0.5 and 1 mil (between 13 and 25 μm) is formed on a superalloy substrate by pack diffusion of Hf at a temperature of 1,975 °F (1,079 °C) for 4 hours.
2. A thin surface layer of Si is deposited by pack siliciding.
3. The hafnided, silicided workpiece is plated with Pt to a thickness between 0.2 and 0.3 mils (between 5 and 8 μm).
4. The workpiece is diffusion heat-treated at a temperature of 1,900 °F (1,038 °C) for 2 hours.
5. The workpiece is vapor-phase or pack aluminized.
6. The workpiece is given a post-aluminiding heat treatment to homogenize the coating.

The superior bond coats afforded by this process enable affected turbine

components to withstand higher operating temperatures; higher operating temperatures result in greater energy-conversion efficiencies. Moreover, the superior bond coats provide some residual protection for parts from which TBCs have spalled.

This work was done by Bhupendra K. Gupta and Jon C. Schaeffer of General Electric Co. for **Lewis Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7–3, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16295.

Reaction-Forming Method for Joining SiC-Based Ceramic Parts

Joints can be formed with tailorable thicknesses, compositions, and thermomechanical properties.

Lewis Research Center, Cleveland, Ohio

A process that involves reaction bonding makes it possible to form strong joints, with tailorable thicknesses and compositions, between high-temperature-resistant structural parts made of SiC-based ceramic materials. These parts and materials are being developed for use as engine components, radiant-heater tubes, heat exchangers, components of fusion reactors, furnace linings, furnace bricks, and components for diffusion processing in the microelectronics industry. The process can be used to join simply shaped parts to make complexly shaped structures, and to repair such parts and structures.

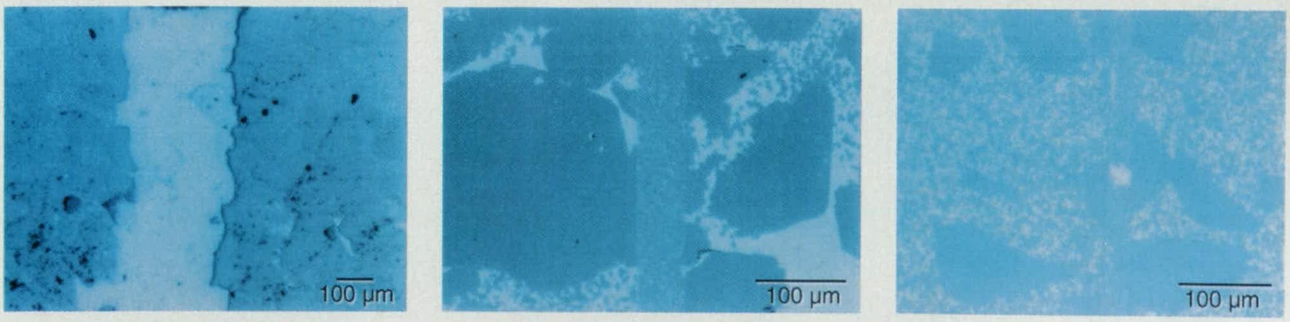
The present process is a successor to the process reported in "Joining of SiC-Based Ceramic and Fiber-Reinforced Composite Parts" (LEW-16405), *NASA Tech Briefs,* Vol. 22, No. 5 (May 1998), page 54. The process begins with the application of a carbonaceous mixture (typically in paste form) to the joint regions between parts, immediately followed by clamping of the parts in a fixture. The thickness of the joint can be tailored by choice of the properties of

the carbonaceous mixture and of the clamping force. The carbonaceous mixture is cured at a temperature between 110 and 120 °C for 10 to 20 minutes. The curing step fastens the parts together (albeit not yet at full strength), making it unnecessary to fabricate a special fixture to hold the parts together during subsequent high-temperature processing.

After curing of the carbonaceous layer, silicon or a silicon alloy in tape, paste, or slurry form is applied to the joint region. Then the parts are heated to a temperature between 1,250 and 1,425 °C for 5 to 10 minutes, the precise temperature and time depending on the applied material. The heating causes the silicon to melt, infiltrate the joint, and react with carbon. As a result, the finished joint contains silicon carbide with amounts of silicon and other phases that can be tailored by choice of the compositions of the reactants. Consequently, the process results in joints with tailorable microstructures and thus tailorable thermomechanical properties. The properties of the joints can thus be tailored to approximate closely those of the joined parts.

The figure depicts the microstructures of selected experimental reaction-formed joints of three different thicknesses between samples of a commercially available reaction-bonded silicon carbide. The thickest of these joints was found to consist mainly of Si with small amounts of SiC, and to be susceptible to brittle fracture. The thinnest of these joints were found to consist of SiC and Si phases. At both room temperature and temperatures up to 1,350 °C in air, the strength of the material in the thinnest joints was found to be at least equal to and, in some cases, greater than, that of the adjacent SiC sample materials.

This work was done by M. Singh of NYMA, Inc., for **Lewis Research Center**.



Joint A (About 350 µm Thick) — Joint B (About 50 to 55 µm Thick) — Joint C (About 20 to 25 µm Thick)

Reaction-Formed Joints of Different Thicknesses between samples of reaction-bonded SiC exhibited different microstructures, compositions, and mechanical properties.

For further information, access the Technical Support Package (TSP) ***free on-line at www.nasatech.com*** *under the Materials category.*

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Room-Temperature, Ultraviolet Curing of Polyimides

Diels-Alder reactions are used to trap unstable intermediate compounds.

Lewis Research Center, Cleveland, Ohio

Polyimides have been used widely in fiber-reinforced composite materials for aerospace components and in thin films for packaging of electronic circuitry. Typically, the synthesis of a material of this type involves the condensation of a diamine with a dianhydride. This synthesis also produces low-molecular-weight byproducts, e.g., water, which can cause problems in processing the polyimide that one seeks to produce. In addition, health concerns about the handling of aromatic diamines — which are often toxic, mutagenic, or carcinogenic — give rise to requirements to use costly engineering controls in the workplace to limit exposure to these compounds.

Over the years, other approaches to the synthesis of polyimides have been developed to address these problems and concerns. Diels-Alder polymerizations — usually involving a bismaleimide and a stable bisdiene, such as a bisfuran — have been investigated extensively. More recent work in this area has focused on the use of reactive diene intermediates, such as *o*-quinodimethanes generated from benzocyclobutenes. To date, most if not all of these approaches have entailed the use of high reaction temperatures (above 200 °C).

A new Diels-Alder route to the synthesis of polyimides involves the use of ultraviolet light, rather than heat, to effect polymerization. This approach is based upon a well-known class of photochemical reactions — the photoenolization of *o*-methylphenyl ketones — which can be carried out at room temperature. For example (see Figure 1) the irradiation of an *o*-methylphenyl ketone (compound 1) with ultraviolet light of wavelengths above 300 nm produces a photoenol (compound 2). This photoenol is unstable, but persists long enough to undergo Diels-Alder reactions with typical dienophiles, such as a maleimide (compound 3).

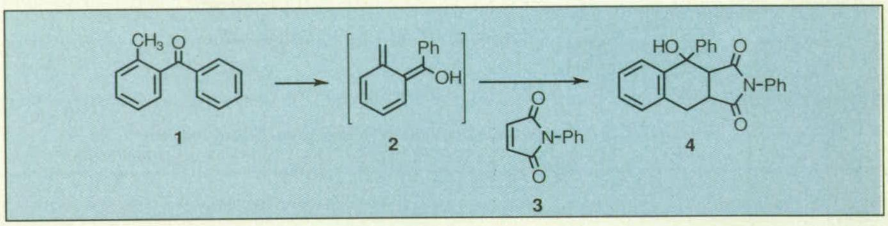

Figure 1. A **Photoenol** (compound 2) is generated from o-methylbenzophenone (compound 1), then trapped by use of a maleimide (compound 3), yielding compound 4.

By utilizing a diketone, such as 2,5-dibenzoyl-*p*-xylene (compound 5) and a bismalemide (compound 6), this chemistry can be used to make polyimides (see Figure 2). A number of polyimides (represented as compound 7), have been prepared by following this approach. Glass-transition temperatures for these polyimides can be as high as 300 °C. These polyimides exhibit modest stabilities in both air and nitrogen. Temperatures of onset of decomposition, measured by thermal gravimetric analysis (TGA), are as high as 400 °C in air and 450 °C in nitrogen. Higher glass-transition temperatures and temperatures of onset of decomposition can be obtained by conversion of compound 7 into compound 8 through acid-catalyzed dehydration followed by dehydrogenation. Polyimides represented as compound 8 have glass-transition temperatures as high as 330 °C and temperatures of onset of decomposition as high as 550 °C in air and 525 °C in nitrogen.

This chemistry has been demonstrated in solution (benzene or cyclohexanone), but should be easily adaptable to achieve solid-state (solvent-free) curing. Such adaptation would make the present ap-

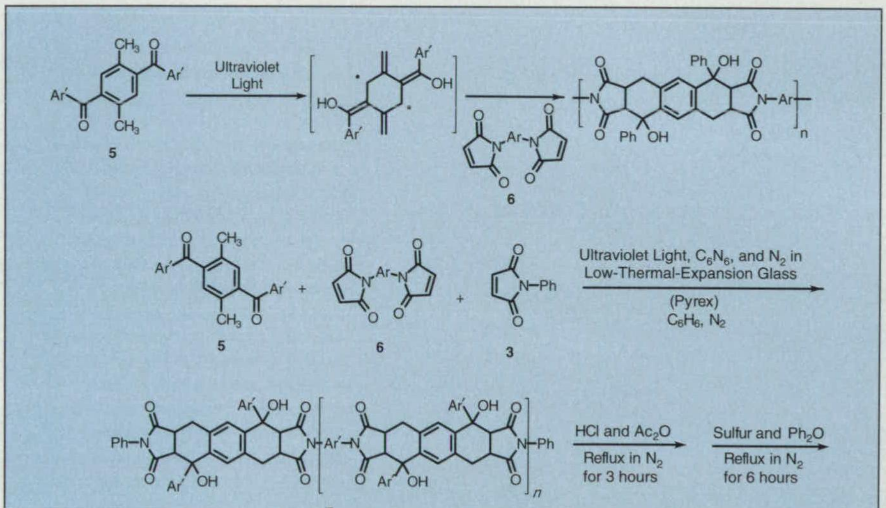

Figure 2. **Polyimides Are Produced** via Diels-Alder trapping of photochemically generated bisdienes.

proach particularly suitable for thin-film applications (e.g., coatings, electronics packaging, and photonic/optical materials). This ultraviolet-curing approach could offer several advantages over other approaches to the preparation of polyimides. Ultraviolet-cured films should undergo less shrinkage during cure than do those films that are cured at high temperatures. This approach would be useful for the curing of polyimides that contain such thermally sensitive groups or additives as nonlinear optical materials. In addition, this approach does not entail some of the disadvantages of condensation-chemistry-based approaches; namely, the formation of volatiles during cure, health risks associated with the use of diamines, and poor solution stability.

This work was done by Michael A. Meador and Mary Ann B. Meador of **Lewis Research Center,** *Lesley L. Williams of Spelman College, and Jeremy R. Jones of NASA Center for High Performance Polymers and Composites, Clark Atlanta University. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category.*

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Software

Software Detects Small Satellites in Spacecraft Imagery

A computer program processes images acquired at different times by instrumentation aboard a spacecraft to detect small satellites of asteroids and other planetary bodies. The program coregisters the images, removes instrument artifacts and images of background stars, and performs a thresholding operation to suppress noise and generate binary versions of the images. The program then searches the binary images for persistent objects, which when found, are put on a list of candidate satellites. The entire process takes place automatically, without human intervention. The data on the candidate satellites can be sent to an autonomous spacecraft executive program for targeting of the spacecraft and/or its instrumentation. The program may also be adaptable to terrestrial use in automated detection of objects and avoidance of hazards. At present, the program runs under Matlab on Sun workstations running Solaris.

This program was written by Paul Stolorz, Victoria Gor, and Richard Doyle of Caltech and Clark Chapman, Randy Gladstone, William Merline, and Alan Stern of the Southwest Research Institute for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Software category. NPO-20201*

Recursive and Adjacency Algorithms for Ranking Hypotheses

A library of computer programs has been developed to solve the problem of parametric ranking of a set of hypotheses on the basis of incomplete and/or uncertain information. In general, the ranking must be learned by use of training examples in which one observes the values of random variables that depend on the hypotheses and adjusts the parameters accordingly. In addition, it is necessary to balance a potential increase in confidence in the ranking against the cost of additional examples. In these programs, the balance is struck by use of a combination of the "probably approximately correct" criterion from the theory of computational learning and the "expected loss" criterion from decision theory and gaming problems. The library offers the option to use a ranking algorithm that performs a recursive selection among the remaining unranked hypotheses, and/or one that performs only pairwise comparisons between adjacent hypotheses. These programs are written in ANSI C++.

This program was written by Steve A. Chien, Andre Stechert, and Darren Mutz of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Information Sciences category. NPO-20170*

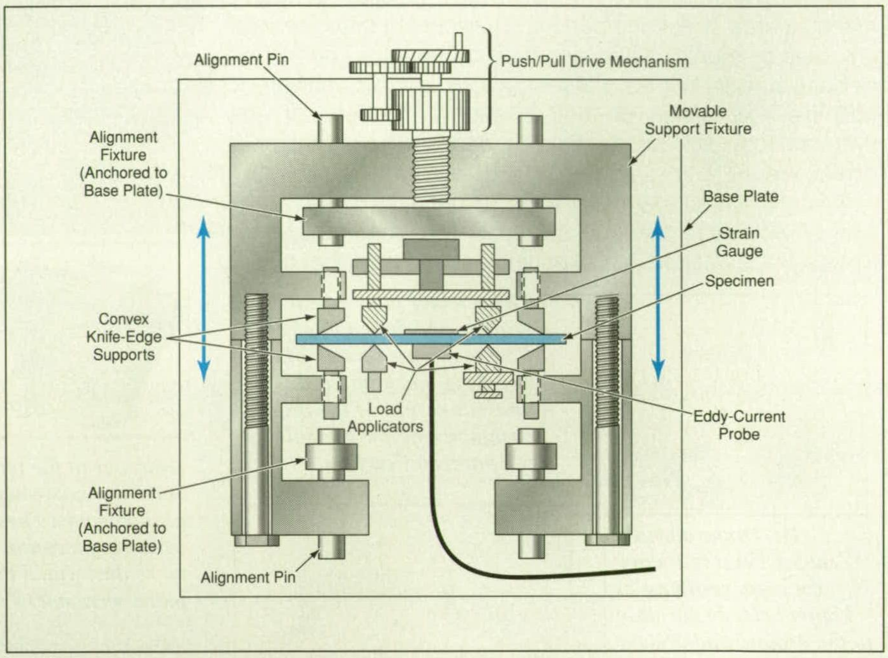
Mechanics

Push/Pull Four-Point-Bending Apparatus

Applied bending stress can be reversed during a test.

Goddard Space Flight Center, Greenbelt, Maryland

The figure depicts an improved apparatus for three- or four-point bending tests of stripe specimens. In a bending test, the specimen is subjected to tension along its top surface and compression along its bottom surface, or vice versa. A three- or four-point bending fixture of older design is capable of pushing from one side only, so that it can bend the specimen in one direction only; that is, it can induce either tension or compression (but not both) on the top or bottom surface. The present apparatus is capable of pushing on a specimen from either side and thus bending the specimen in either direction. Thus, for example, the apparatus can be used to perform a test in which the applied stress is varied continuously from a maximum tension through zero to a maximum compression.



The **Specimen Can Be Bent Up, Down, or Both** during a test in this four-point bending apparatus.

The specimen is placed between two pairs (for a four-point test) or one pair (for a three-point test) of knife-edge load applicators that are anchored on a base plate. One load applicator is fixed; the other three are adjustable. Pairs of convex knife-edge supports on a movable support fixture are also positioned in gentle contact (while in the zero-applied-stress condition) with the specimen near the ends of the specimen.

A manual push/pull drive mechanism translates the movable support fixture up or down to exert a compressive or tensile stress on the upper or lower surface of the specimen. Alignment pins ensure that the stress is applied perpendicularly to the nominal longitudinal axis of the specimen. A strain gauge is attached to one side of the specimen and an eddy-current probe (or other sensor) to the other side. During the bending test, the eddy-current signal is recorded as a function of the strain. The eddy-current signal as a function of stress and/or strain yields information on residual stress in the specimen. Optionally, the apparatus could be automated by motorizing the drive mechanism and using the output of the strain gauge as a feedback control signal for the motor.

This work was done by E. James Chern of **Goddard Space Flight Center.** *No further documentation is available.*
GSC-13801

Noise-Reducing Fairings for Flush-Mounted Microphones

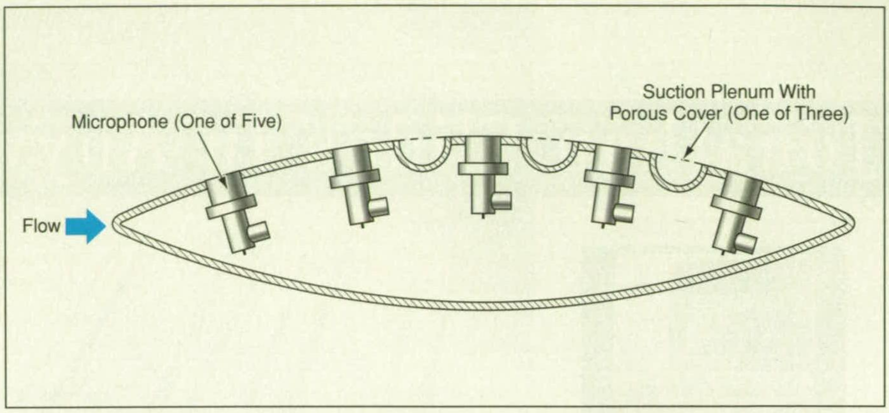
Noise is minimized by designs that favor laminar over turbulent flow.

Ames Research Center, Moffett Field, California

Streamlined fairings have been invented for housing single or multiple microphones to measure noise in flowing gases and liquids. Each fairing of this type is designed to minimize the spurious (background) component of noise generated by local flow disturbances caused by the fairing itself. These fairings could be used in measuring noise associated with a variety of flow sources, including aircraft, wind tunnels, air-handling equipment, and land vehicles.

The figure presents a cross section of a representative fairing of the present type. The microphones are mounted flush with the outer fairing surfaces to minimize acoustic distortion; in fairings invented previously for the same purpose, the microphones are typically mounted within recesses or cavities, the acoustic resonances of which distort the desired acoustic signals. Also, unlike some previously invented fairings, the microphones are not mounted behind porous screens that attenuate the desired acoustic signals. The outputs of the microphones are communicated to measuring or recording equipment via electrical or fiber-optic cables, or by telemetry.

To minimize the local flow disturbances that generate background noise, a fairing of this type is designed to obtain laminar flow under the widest practical range of anticipated flow conditions. In the example illustrated in the figure, the shape of the fairing and its orientation with respect to the flow are chosen to obtain an extended upstream surface with a favorable pressure gradient (pressure on the fairing surface decreasing with distance from the leading edge).The flow in a favorable pressure gradient tends to be naturally smooth or laminar over a wide range of speed; consequently, microphones placed in this region are exposed to minimum noise from local flow disturbances.



A conceptual illustration shows **Sensor Fairing** with five flush-mounted microphones with natural laminar flow upstream of the point of maximum thickness, and suction flow control to delay the onset of unsteady separation downstream of the point of maximum thickness. Suction flow control may also be used to maintain laminar flow to higher velocities and free-stream turbulence levels. In recent tests, natural laminar flow was maintained on the forward section of a fairing with 8 in. (0.2 m) chord to speeds of 100 kn (51.4 m/s) with free-stream turbulence level of 0.25 percent.

Above a critical speed that depends on the roughness of the fairing surface and the disturbance content of the free-stream flow, the flow along the upstream surface undergoes a transition from laminar to turbulent. The transition speed can be increased by cooling and/or by suction through small holes, slots, or porous surfaces; this phenomenon is well known in the aircraft industry and has been exploited to reduce drag on aerodynamic surfaces. Here, suction is applied to maintain laminar flow at speeds that would otherwise exceed the transition speed.

The pressure along the fairing surface downstream of the point of maximum thickness is increasing with downstream distance. The flow in this adverse pressure-gradient region tends to be turbulent at most speeds of interest, and the flow may separate from the fairing. Unsteady separation may cause an increase in drag and levels of self-noise. Suction control may also be used to delay the onset of flow separation at the trailing edge.

This work was done by William Clifton Horne and Kevin D. James of **Ames Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mechanics category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Ames Research Center; (650) 604-5104. Refer to ARC-14241.

Engines for Remotely Piloted Atmospheric-Science Airplanes

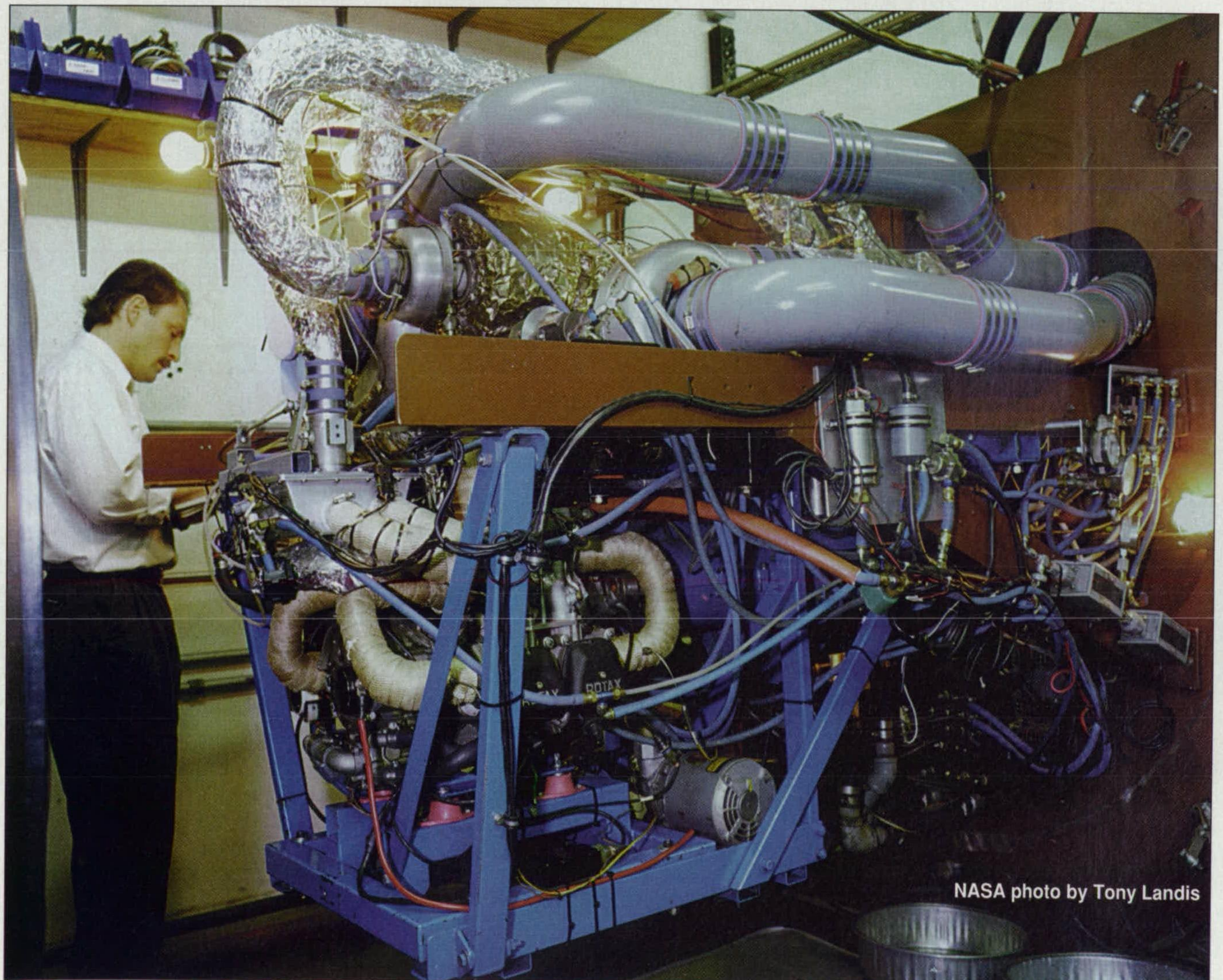
A reciprocating engine is a better answer in high-flight altitude.

Dryden Flight Research Center, Edwards, California

A spark-ignited reciprocating gasoline engine, intake-pressurized with three cascaded stages of turbocharging, was selected by NASA's Environmental Research Aircraft and Sensor Technology (ERAST) Program, managed at the Dryden Flight Research Center, to propel the next generation of remotely piloted atmospheric-science airplanes. Scientific needs for sampling the atmosphere, and providing unique images of the Earth, dictate the unique required flight regime; namely, subsonic speeds at altitudes >80 kft (>24 km) and for periods exceeding 24 hours.

The unique nature of the sampling mission, coupled with the economics of engine development, point to the turbocharged, spark-ignited reciprocating engine (see figure) as the only cost-effective option. The table shows the subtle physical advantages of the reciprocating engine over the turbojet for high-altitude, low-speed flight, arising from its near-stoichiometric combustion. Its low specific air consumption reduces the amount and weight of turbomachinery required to generate power at >80 kft, which apparently results in lower weight and lower thrust specific fuel consumption than a turbojet in this flight regime, despite the large heat exchangers.

The turbocharged engine is low cost because of the existing technology base of mass-produced automotive and general aviation hardware that can be adapted to build such an engine. In addition, the turbocharged engine is technically competitive with the turbine engine at high altitudes. Although the power density of a turbine engine is



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J97 Turbojet at M = 0.80	715 lbm	Flameout	------	------
New Turbojet at 0.5<M<0.85	920 lbm	190 lbf	4.8 lbm/lbf	0.80 lbm/hr per lbf
Strato 2C (3-Stage TCSI) at M = 0.5	2457 lbm	360 lbf	6.8 lbm/lbf	0.44 lbm/hr per lbf
80K ERAST 3-Stage TCSI at M = 0.4	587 lbm	91 lbf	6.5 lbm/lbf	0.44 lbm/hr per lbf
At 90 kft				
New Turbojet at 0.5<M<0.85	920 lbm	120 lbf	7.7 lbm/lbf	0.80 lbm/hr per lbf
90K ERAST 3-Stage TCSI at M = 0.4	667 lbm	90 lbf	7.4 lbm/lbf	0.44 lbm/hr per lbf

Subtle Physical Advantages of the reciprocating engine are shown here over the turbojet for high-altitude, low-speed flights.

higher than the reciprocating engine at normal altitudes, the reciprocating engine begins to compare favorably with turbine engines at altitudes above 80 kft, especially at the lower speeds where inlet precompression is not available.

This work was done by James L. Harp, Jr., of ThermoMechanical Systems, Inc., with contributions from NASA Lewis Research Center for **Dryden Flight Research Center.** *To obtain a copy of the paper, "Propulsion System for Very High Altitude Subsonic Unmanned Aircraft," access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Machinery/Automation category.*

Inquiries concerning rights for its commercial use should be addressed to:

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Mounting Heater Wires on Glass Capillary-Heat-Transfer Tubes

The heaters performed flawlessly.

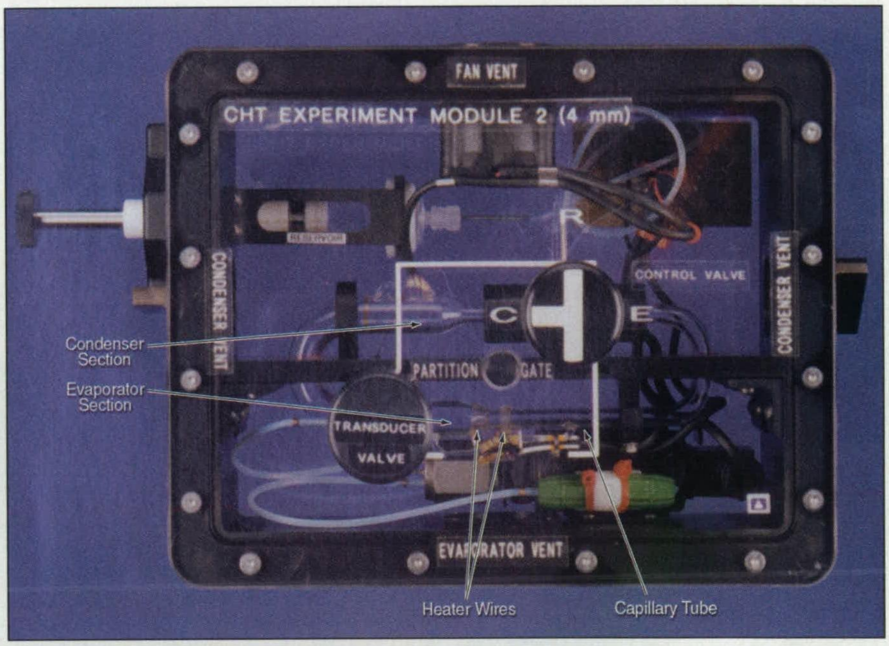
Lewis Research Center, Cleveland, Ohio

Two mounting schemes were devised for attaching heater wires to special-purpose glass tubing used in a capillary-heat-transfer experiment. Not only were the wires required to supply heat needed for the experiment; in addition, it was required that the liquid and vapor enclosed by the tubing be visible between the wires. It was a challenge to satisfy these requirements while preventing (1) delamination of wires from the tubing and (2) short-circuiting that can occur as a consequence of delamination. Finally, neither the attachment nor the operation of the heaters could be allowed to impose stresses that could break the tubing.

The tubing was made from a low-thermal-expansion glass. The heater wires were made of a Cr/Co/Al/Fe alloy and had a diameter of 0.010 in. (0.25 mm). The problem was to mount one heater wire on a cylindrical section of capillary tube and the other wire on a conical transition between the capillary tube and wider evaporator/condenser tube (see figure).

Part of the solution to the wire-mounting problem was to prepare the capillary tube separately from the evaporator/condenser tube before bending the tubes and joining them to form the flow loop needed for the experiment. The main step in the separate preparation of the capillary tube was grinding a spiral groove, in which the heater wire would later be inserted. The spiral groove was intended to prevent adjacent turns of wire from sliding together and thereby becoming short-circuited. An additional advantage of placing the wire in the groove is that it increased the effective contact area between the wire and the tube, making for greater efficiency in the transfer of heat from the wire to the glass.

Once the groove was ground, the capillary and evaporator/condenser tubes were bent and then joined, with conical transition pieces, in a glass-blowing operation. A glass rod (not shown in the figure) was installed alongside the glass tubing to provide additional support for the capillary heater wire. The glass loop was stress-relieved. The capillary heater wire was inserted in the groove, then encapsulated in the groove by epoxy and a two-piece glass cover, which aided heat transfer while affording the required transparency.



Heater Wires were mounted on adjacent cylindrical and conical portions of glass tubing used in a capillary-heat-transfer experiment.

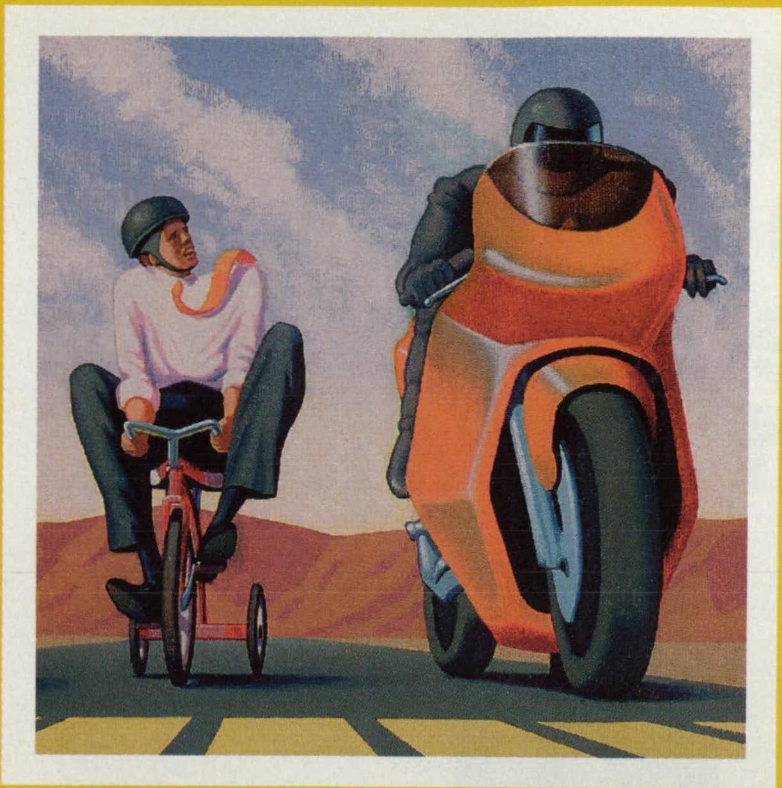
The end portions of the heater wire were made to pass through two short ceramic tubes attached to the glass rod. The tips of the capillary heater wire were welded to copper wires, which were wider than the holes in the ceramic tubes; this arrangement prevented unwrapping of the capillary heater wire. The capillary-heater-wire installation stayed intact even when the heater was operated beyond the maximum use temperature of the epoxy.

Because the conical transition pieces were formed manually, they had irregular shapes, making it impractical to grind a spiral groove to hold a heater wire at the capillary/evaporator transition. Instead, all except the end portions of the wire for this location was bent in a serpentine configuration, then wrapped around the glass, then epoxied in place on the glass at each bend in the wire. The end portions of the wire were fed through a two-hole piece of ceramic and welded to larger wires; this arrangement prevented unwrapping and short-circuiting of the wire.

No failures of glass tubing were caused by the installation and operation of the heaters. Measurements by thermocouples confirmed that heat was transferred from the heater wires to the liquid in the glass. The heaters remained in contact with the glass, operating flawlessly throughout the capillary-heat-transfer experiment.

This work was done by Greg Blank of **Lewis Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Manufacturing/Fabrication category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16707.



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Physical Sciences

Model of a Drop of O_2 Surrounded by H_2 at High Pressure

This model accounts for complex phenomena that are not represented in older models.

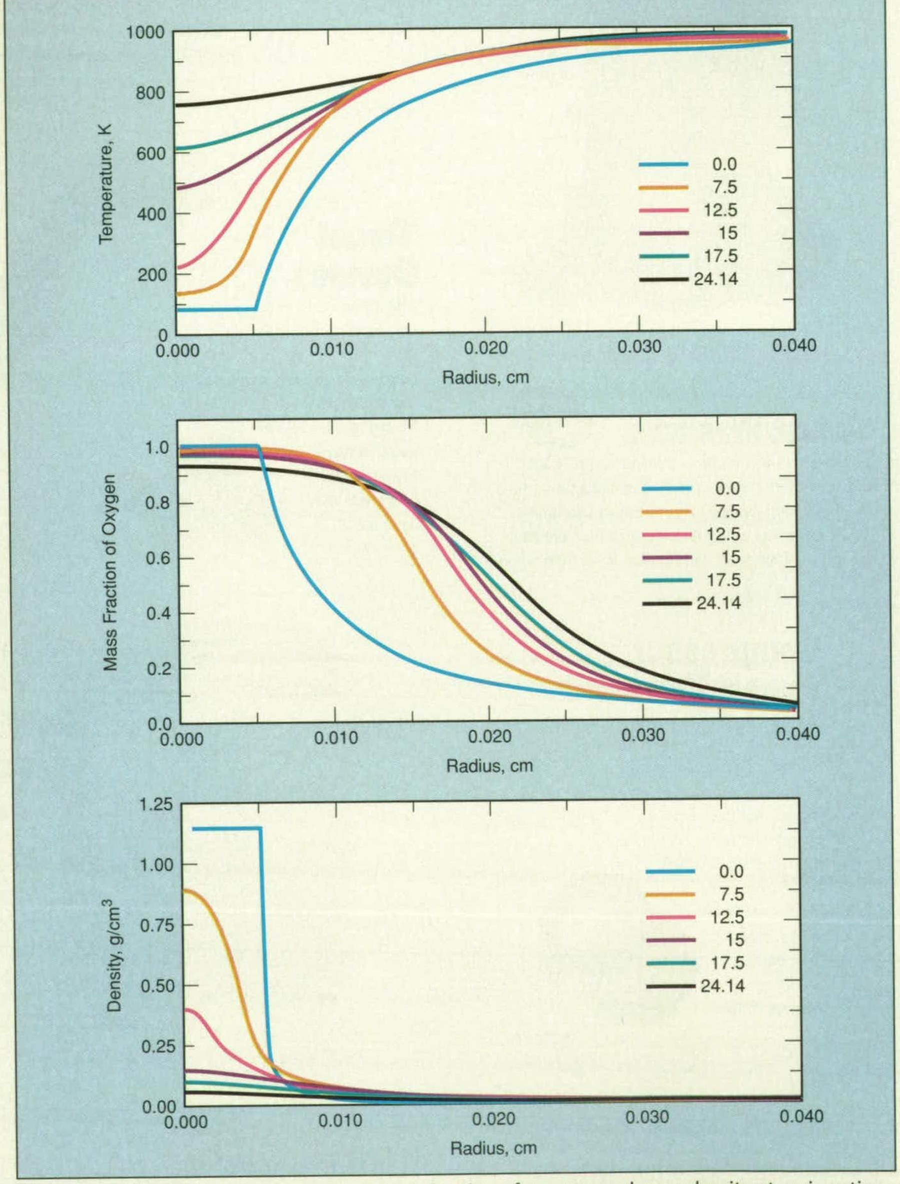
NASA's Jet Propulsion Laboratory, Pasadena, California

A mathematical model has been developed to predict the behavior of an isolated drop of a first fluid surrounded by a second fluid, under quiescent conditions at supercritical temperature and pressure. The model has been specialized to represent the behavior of a drop of liquid oxygen surrounded by hydrogen under supercritical conditions like those encountered in a rocket-engine combustion chamber. According to plans, this model will eventually be combined with other models to form a comprehensive model for the behavior (including combustion) of hydrogen and oxygen in a rocket-engine combustion chamber.

None of the related conventional mathematical models of the behavior of oxygen could represent the complex phenomena that occur in a rocket-engine combustion chamber. The conventional models are based, variously, on empirical correlations or on physics under subcritical conditions. The common weakness of the conventional models is failure to represent the physics under supercritical conditions.

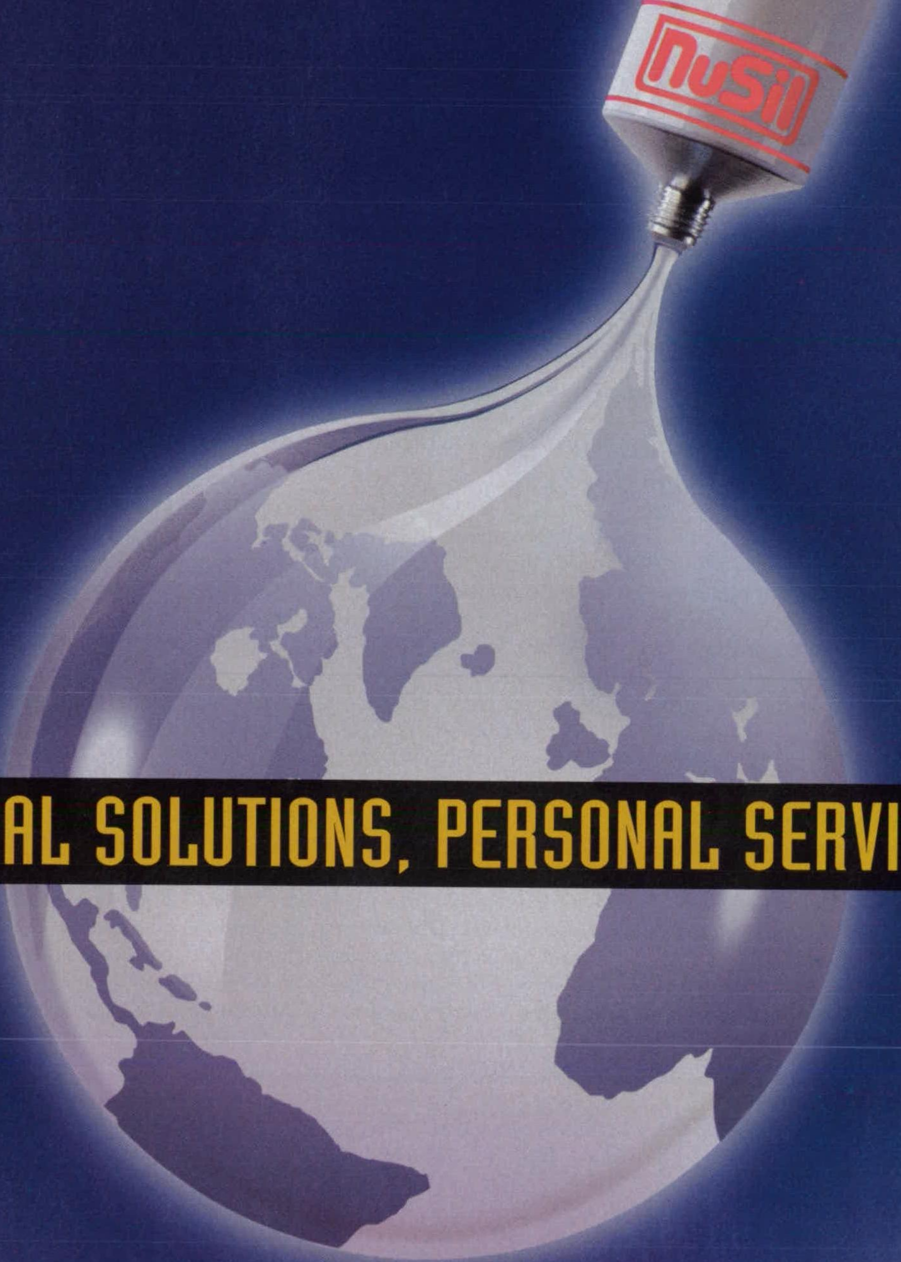
The present model incorporates physics from first principles. It is based on fluctuation theory that incorporates equations for the conservation of momentum, mass for each molecular species, and enthalpy. The advantage of the theory is that it inherently accounts for nonequilibrium processes and naturally leads to the most general fluid-dynamical equations in which the heat flux and the partial molar fluxes are related to thermodynamic quantities (e.g., temperatures and chemical potentials). The relationships among these quantities are expressed using transport (diffusion)-matrix formulation. This formulation includes the Soret effect (transport of species due to thermal gradients) and the Dufour effect (transport of heat due to gradients in concentrations of species). The conservation equations are coupled with a law of kinetics for mass release, with equations of state, and transport coefficients that are accurate over the sub-critical and adjacent supercritical ranges for both fluid oxygen and hydrogen.

The Soret and Dufour effects, along with thermodynamic nonequilibrium effects, are not taken into account in the conventional models. The inclusion of these effects in the present model results in modifications of length scales for heat and mass transfer, with important consequences for designing combustion chambers.



These **Spatial Variations** of temperature, mass fraction of oxygen, and mass density at various times were calculated by use of the model for an initial liquid-oxygen drop radius of 50 µm, a sphere-of-influence radius of 1 mm, an initial drop-surface temperature of 100 K, an initial temperature of 1,000 K at the edge of the sphere of influence, and a pressure of 20 MPa. The times are indicated on the graphs in milliseconds.

Numerical results obtained using this model show that under supercritical conditions, the behavior of the liquid-oxygen/hydrogen system is one of slow diffusion. The temperature profile relaxes fastest, followed by the density profile and then by the mass-fraction profile (see fig-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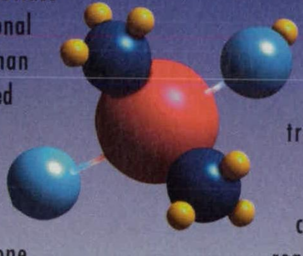


ure). An effective Lewis number estimated according to the theory described in the following article is found to be about 40 times the traditional Lewis number. Parametric studies reveal that gradients increase with increasing drop size, increasing pressure, or decreasing temperature; the practical consequence of this finding is that increased turbulence is needed to mix the hydrogen and oxygen at increased pressure.

This work was done by Josette Bellan and Kenneth Harstad of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.* NPO-20220

The Lewis Number Under Supercritical Conditions

An effective Lewis number differs from the traditional Lewis number.

NASA's Jet Propulsion Laboratory, Pasadena, California

An effective Lewis number has been defined for two-fluid mixtures under conditions of (1) supercritical temperature and pressure and (2) large gradients of temperature and composition. The Lewis number is a measure of the ratio between characteristic lengths for diffusion of heat and diffusion of mass. The traditional definition of the Lewis number for a fluid is straightforward under subcritical conditions, in which the molar flux depends only on mole-fraction gradients and the heat flux depends only on the temperature gradient. Under supercritical conditions, the traditional definition of the Lewis number does not account for additional heat- and mass-transfer effects and thus leads to inaccurate estimates of heat- and mass-transfer scales. Accurate estimates of these scales are needed for designing combustors that operate under supercritical conditions; for example, combustors in rocket, gas turbine, and Diesel engines.

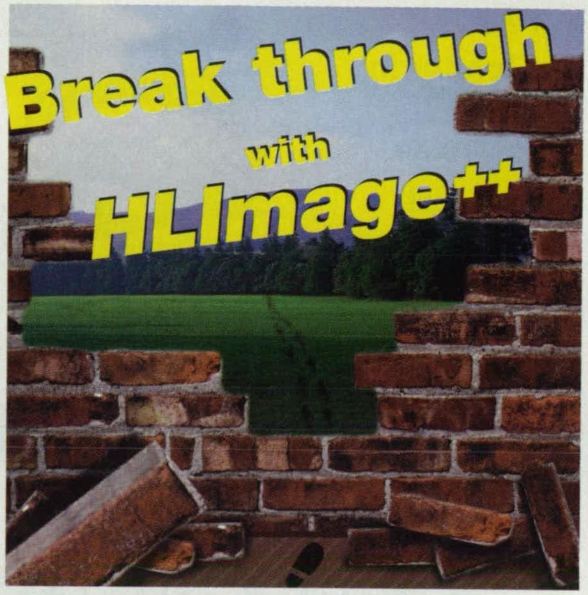
The need for an effective Lewis number (as distinguished from the traditional Lewis number) becomes apparent in the context of the fluctuation-dissipation theory described in the preceding article. In that theory, the Soret and Dufour effects are described by terms that include the off-diagonal elements of the transport matrix. The differential operators and equations for mass fractions and temperature are coupled through the off-diagonal elements in that the diffusion terms in each equation include derivatives of both dependent variables. This coupling through the off-diagonal elements prohibits a simple definition of diffusion length scales for heat and mass transfer and represents additional contributions to heat and mass transfer that are not considered in the traditional Lewis number. These observations suggest the need for an effective Lewis number that is valid under general (including supercritical) conditions.

The traditional Lewis number relates the diffusion lengths of the mass fractions and temperature as given by the coefficients of the diffusive terms. In the classical situation in which the traditional Lewis number is defined, the differential operators for mass fractions and species are uncoupled, and so the diffusion terms in the differential operators can be expressed as the product of a diagonal matrix and a spatial derivative. In order to be able to define an effective Lewis number in the general case, one must find equivalent variables for which the matrix of the differential equations assumes a diagonal form.

Given the complexity of the equations, a simple, accurate combination of variables cannot be found *a priori*. Therefore, a solution was sought for the special case of a drop of liquid (e.g., liquid oxygen) surrounded by a gas (e.g., hydrogen) under simplifying assumptions of (1) a boundary-layer spatial variation under subcritical conditions that exist in a thin radial interval at the surface of the drop and (2) quasi-steady behavior. The adoption of this special case makes it possible to define equivalent variables in the forms of linear combinations of the temperature and the mass fraction of one species, that yield the desired decoupling between differential equations for temperature and mass fractions.

Numerical results from calculations for binary fluid systems, variously involving isolated or interacting fluid drops, show that the effective Lewis number can be as much as 40 times the traditional Lewis number, and that the spatial variations of the two numbers

Machine Vision and Image Processing Software



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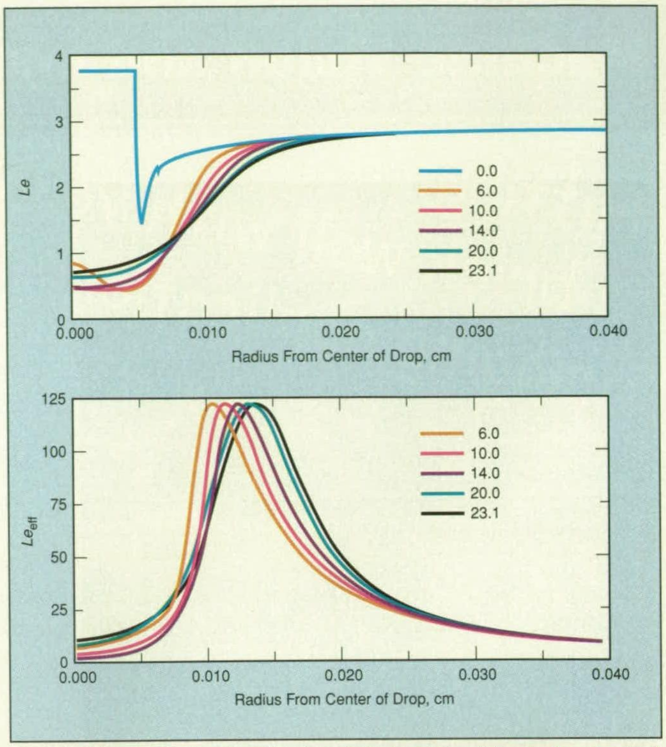


The **Effective Lewis Number (Le_{eff}) and the Traditional Lewis Number (Le)** were calculated at various times for isolated liquid-oxygen drop with an initial radius of 50 μm, a sphere-of-influence radius of 1 mm, an initial drop-surface temperature of 100 K, an initial temperature of 1,000 K at the edge of the sphere of influence, and a pressure of 80 MPa. The times are indicated on the graphs in milliseconds.

are different (see figure). Thus, the traditional Lewis number cannot be relied upon to give even a qualitatively correct approximation of heat- and mass-transfer scales under supercritical conditions.

This work was done by Josette Bellan and Kenneth Harstad of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at*** ***www.nasatech.com*** *under the Physical Sciences category. NPO-20256*

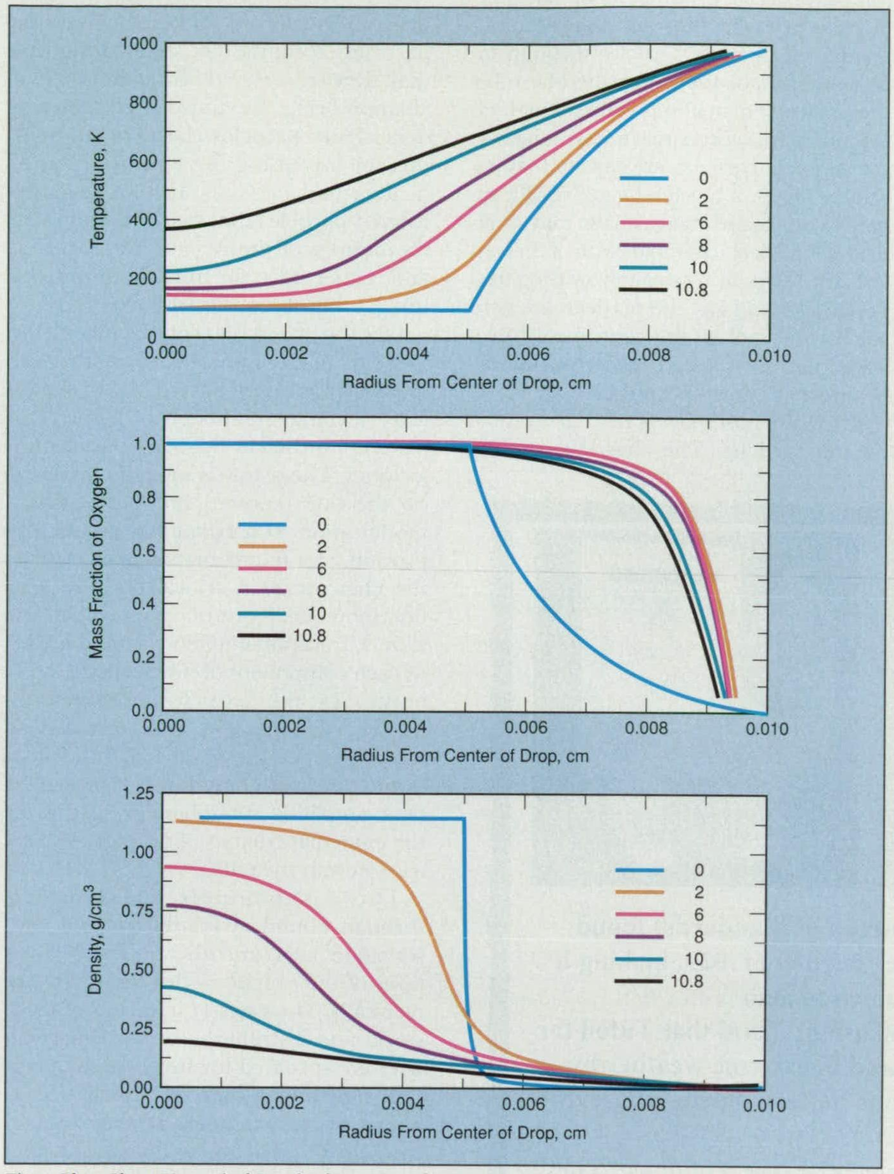
Model of Interacting O_2 Drops Surrounded by H_2 at High Pressure

This model accounts for collective behavior, which affects stability or instability of combustion.

NASA's Jet Propulsion Laboratory, Pasadena, California

A mathematical model has been developed to predict the behavior of mutually interacting drops of a first fluid surrounded by a second fluid, under quiescent conditions at supercritical temperature. The model has been specialized to represent the behavior of drops of liquid oxygen surrounded by hydrogen under supercritical conditions like those encountered in a rocket-engine combustion chamber.

The drops of liquid oxygen are formed by atomization from jets of liquid oxygen. There is considerable experimental evidence that the atomization process forms the drops in clusters, and that the drops interact within each cluster. The interaction among drops affects the stability of combustion process. Therefore, a model like the present one is needed for designing



These **Plots Show Numerical Results** from one of a number of example calculations performed by use of the model. The basic parameters in this example were an initial liquid-oxygen drop radius of 50 μm, initial sphere-of-influence radius of 100 μm, initial cluster radius of 2 cm, equivalent Nusselt number of 100, initial drop-surface temperature of 100 K, initial temperature of 1,000 K at the edge of the sphere of influence and outside the cluster, pressure of 20 MPa, and no oxygen outside the cluster. Times are indicated on the graphs in milliseconds.

combustors, and for analyzing and controlling their operation.

The situation represented by the present interacting-drop model is that of a cluster of a finite number of drops of one fluid (which could be liquid oxygen) immersed in another fluid (a dense gas that could be hydrogen). All the drops are assumed to be spheres of same radius, and each drop is assumed to reside in a fictitious sphere of influence with a radius equal to half the distance to the nearest neighbor drop in the cluster. The interstitial region between the spheres of influence is assumed to be uniform and quiescent with respect to the cluster. Each sphere of influence contains one drop and its surrounding fluid, and has fixed mass; this means that the sphere of influence expands or contracts in response to variations in temperature.

The behavior of a drop within its sphere of influence is represented by the isolated-drop model described in the first of the two preceding articles — "Model of a Drop of O_2 Surrounded by H_2 at High Pressure" (NPO-20220). The interactions among drops and the resulting collective behavior of the drops are represented by using equations for the conservation of total mass, conservation of the mass of each fluid, and conservation of energy in the interstitial region to establish boundary conditions for the spheres of influence. Transfers of heat and mass to the cluster are modeled via a Nusselt-number formulation.

Numerical results from calculations for the liquid-oxygen/hydrogen system (see figure) show that the behavior of a cluster is insensitive to variations of the Nusselt number over 3 orders of magnitude. The results also show that at fixed pressure, the accumulation of oxygen in the interstitial region increases with decreasing distance between drops. At fixed initial distance between drops, the gradients of dependent variables become increasingly smeared as pressure increases; this behavior is qualitatively the opposite of that observed for isolated drops. From these observations it is inferred that clusters of drops might be desirable in supercritical combustion because they aid mixing of reactants.

This work was done by Josette Bellan and Kenneth Harstad of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*
NPO-20257

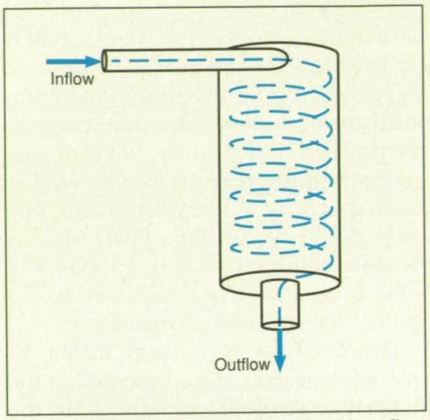
Mathematical Model of Vortex Pyrolysis of Biomass

Numerical simulations provide guidance for designing efficient reactors.

NASA's Jet Propulsion Laboratory, Pasadena, California

A mathematical model has been developed for analyzing the steady-state performances of vortex pyrolysis reactors used to convert particles of raw biomass materials (usually small wood chips) into char, tar, and gas. Optimal designs are usually considered to be those that maximize the production of tar. This model and its submodels can be regarded as more highly evolved versions of the model and submodels described in "Mathematical Model of a Direct-Contact Pyrolysis Reactor" (NPO-20069), "Mathematical Model of Pyrolysis of Biomass Particles (NPO-20070), "Generalized Mathematical Model of Pyrolysis of Plant Biomass" (NPO-20068), and "Production of Tar in Pyrolysis of Large Biomass Particles" (NPO-20067), *NASA Tech Briefs*, Vol. 22, No. 2 (February 1998).

Vortex reactors have been investigated



A **Vortex Reactor** features a strong swirling flow of gas and particles, with resultant direct-contact ablation and rapid heating.

for commercial production of tar from biomass because they are able of rapid heating of biomass particles through direct-contact ablation, and thereby offer the potential to achieve relatively high efficiencies. In a vortex reactor (see figure), the biomass particles are injected, along with a flow of a hot feed gas (usually, superheated steam), tangentially into a vertical cylindrical chamber with a heated wall. In the resulting strongly swirling flow of particles and gas, the particles are held against the wall by the centrifugal force. Thus, the particles are heated primarily by direct conduction from the wall.

Pyrolysis causes layers of char to form on the particles. The char layers could retard pyrolysis because they are partially thermally insulating, but, as the particles continue to slide along the wall, they are scraped off (ablated). This ablation brings the unpyrolyzed remainders of the particles closer to the wall, thereby increasing the effective rates of heating and pyrolysis. Incompletely pyrolyzed particles that reach the outlet at the bottom of the reactor are collected and reinjected at the inlet along with the hot gas and the raw feedstock.

Like the previously reported model, the present mathematical model for the steady-state performance of the vortex reactor includes submodels of pyrolysis of particles, turbulent flow, and particle trajectories. The pyrolysis submodel is based on the one reported previously, with a modification to account for ablation by providing for fragmentation of char when the char attains a critical porosity. The flow submodel is one of compressible flow with a transport-equation sub-submodel of each component of the Reynolds stress tensor. In the particle-trajectory submodel, each particle is represented as moving under the combined influences of the flow (with drag forces represented by a simplified sub-submodel of flow in the immediate vicinity of the particle) and friction with the wall.

These submodels are coupled through boundary conditions and conservation laws, and the resulting equations of the overall model are solved numerically. The rates of injection of feedstocks and distribution of initial particle sizes are specified for steady-state operation. The distribution of particle sizes is altered as particles make repeated passes through the reactor, so that steady-state operation is characterized by, among other things, multiple particle-size distributions, each representing particles at a different stage of pyrolysis.

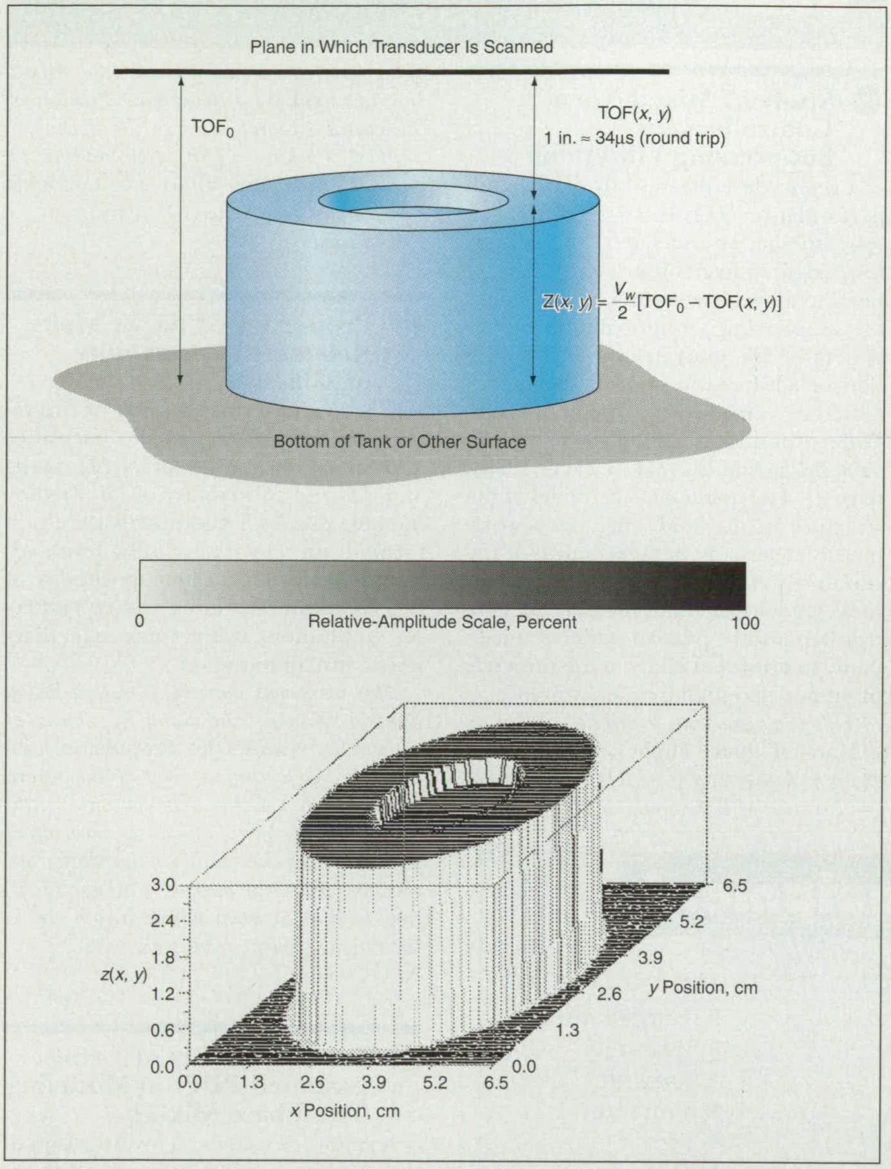
Numerical simulations that have been performed thus far with this model have yielded information pertinent to designing vortex pyrolysis reactors. In particular, a wall temperature of about 900 K was found to maximize tar yield; this temperature is practically independent of initial particle sizes. Analysis of the numerical results also revealed that a small reactor could not be scaled up successfully, so that it is recommended that pyrolysis at industrial scales (large mass feed rates) should be envisaged by using multiple small reactors operating in parallel rather than a single large reactor.

This work was done by Josette Bellan and Richard Miller of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*
NPO-20258

Ultrasonic Profiling of an Object

An additional use for an ultrasonic scanning apparatus has been found.

Goddard Space Flight Center, Greenbelt, Maryland



The **Top Surface of the Object** can be profiled or mapped by use of the time of flight of an ultrasonic signal as a function of horizontal position *x,y*.

A computer-controlled ultrasonic C-scan instrumentation system that was developed primarily for use in finding defects inside solid material specimens can also be used to obtain three-dimensional profiles of the top surfaces of such specimens. In some applications, ultrasonic profiling by use of this system might be an attractive alternative to profiling by use of calipers, linear variable-differential transformers, coordinate-measuring machines, laser profilometers, and other instruments.

The present ultrasonic instrumentation system was described in "Apparatus for Advanced Ultrasonic C-Scan Imaging" (GSC-13524), *NASA Tech Briefs*, Vol. 21, No. 4 (April 1997), page 34. To recapitulate: The system includes an ultrasonic transducer that is scanned in a horizontal (x,y) plane and that is connected to an electronic pulser/receiver, a dual timing gate, a peak detector, and a universal timer. At each position x,y along the scan, the computer estimates the depth of any feature that reflects ultrasound, using the known or assumed speed of sound and the measured round-trip travel time (also called "time of flight," or "TOF" for short) of the ultrasonic signal. The peak detector operates with a time gate chosen so that its output indicates the amplitude of the signal reflected from the feature of interest at x,y. Once the scan has been completed, the computer processes the x,y scanning-position data and the associated depth and amplitude data into a single three-dimensional-appearing plot that shows both depth and amplitude as functions of x and y.

The figure illustrates the use of the system for profiling. An object to be profiled is placed on the bottom of a tank of water with the surface of interest facing upward. The transducer is immersed in the water so that its x,y scanning plane lies at a convenient height above the object. For the purpose of profiling, the TOF to measure is the round-trip travel time for ultrasound that originates at the transducer and that is reflected from the top surface of the object back to the transducer. Then the local height of the object is given by

$$Z(x,y) = (V_w/2)\,[TOF_0 - TOF(x,y)],$$

where V_w is the speed of sound in water, TOF_0 is the round-trip travel time observed when the object is not present or when the transducer is not over the object and is aimed at the surface on which the specimen sits, and $TOF(x,y)$ is the round-trip travel time for position x,y.

This work was done by E. James Chern of **Goddard Space Flight Center**. *No further documentation is available.*
GSC-13911

Books & Reports

Study of Mixed-Norm Controllers for Suppressing Vibrations

A report describes a study of nominal-performance (H_2), robust-performance (μ-synthesis), and mixed H_2/μ methods for designing fixed-order controllers applied to an active-tendon control system for suppressing seismic vibrations in a structure. The study involves an application of advances in control theory discussed in "Mixed-Norm Design of Fixed-Order Controllers" (MFS-26404), *NASA Tech Briefs,* Vol. 20, No. 5 (May 1996), page 91. The mathematical model of the structure in the study includes a parametric uncertainty representative of uncertainty in the frequency of each structural vibrational mode within the control bandwidth, plus an additive uncertainty to provide stability in the presence of unmodeled high-frequency modes.

This work was done by Mark S. Whorton of **Marshall Space Flight Center** *and Anthony J. Calise and C.-C. Hsu of the Georgia Institute of Technology. To obtain a copy of the report, "A Study of Fixed Order Mixed Norm Designs for a Benchmark Problem in Structural Control," access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Systems category.*
MFS-27331

Properties of Ni/Zr Melts Related to Formability of Glasses

A report describes a study of the relationships between (1) the viscosities and specific volumes of Ni/Zr melts and (2) the formability of Ni/Zr-alloy metallic glasses. Experiments were performed on electrostatically levitated, radiantly heated molten specimens of two compound-forming and two eutectic Ni/Zr alloys, using noncontact diagnostic instrumentation.

This work was done by Won-Kyu Rhim, Kenichi Ohsaka, and Sang K. Chung of Caltech for **NASA's Jet Propulsion Laboratory.** *To obtain a copy of the report, "The Specific Volumes and Viscosities of the Ni-Zr Liquid Alloys and their Correlation with the Glass Formability of the Alloys," access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*
NPO-20368

On the Validity of Using Assumed PDFs in Modeling Two-Phase Mixing

A report describes an investigation of the validity of using statistical methods based on single-point probability density functions (PDFs) in mathematical modeling of mixing between a turbulently flowing carrier gas and the vapor from liquid drops suspended in the gas. The investigation included theoretical analysis and comparisons with results of direct numerical simulations (DNS) of a two-phase mixing layer.

This work was done by Josette Bellan and Richard S. Miller of Caltech for **NASA's Jet Propulsion Laboratory.** *To obtain a copy of the report, "On the Validity of the Assumed PDF Method for Modeling Binary Mixing/Reaction of Evaporated Vapor in Gas/Liquid-Droplet Turbulent Shear Flow," access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*
NPO-20431

Stable, Soft-Opening/Soft-Closing Pressure-Relief Valves

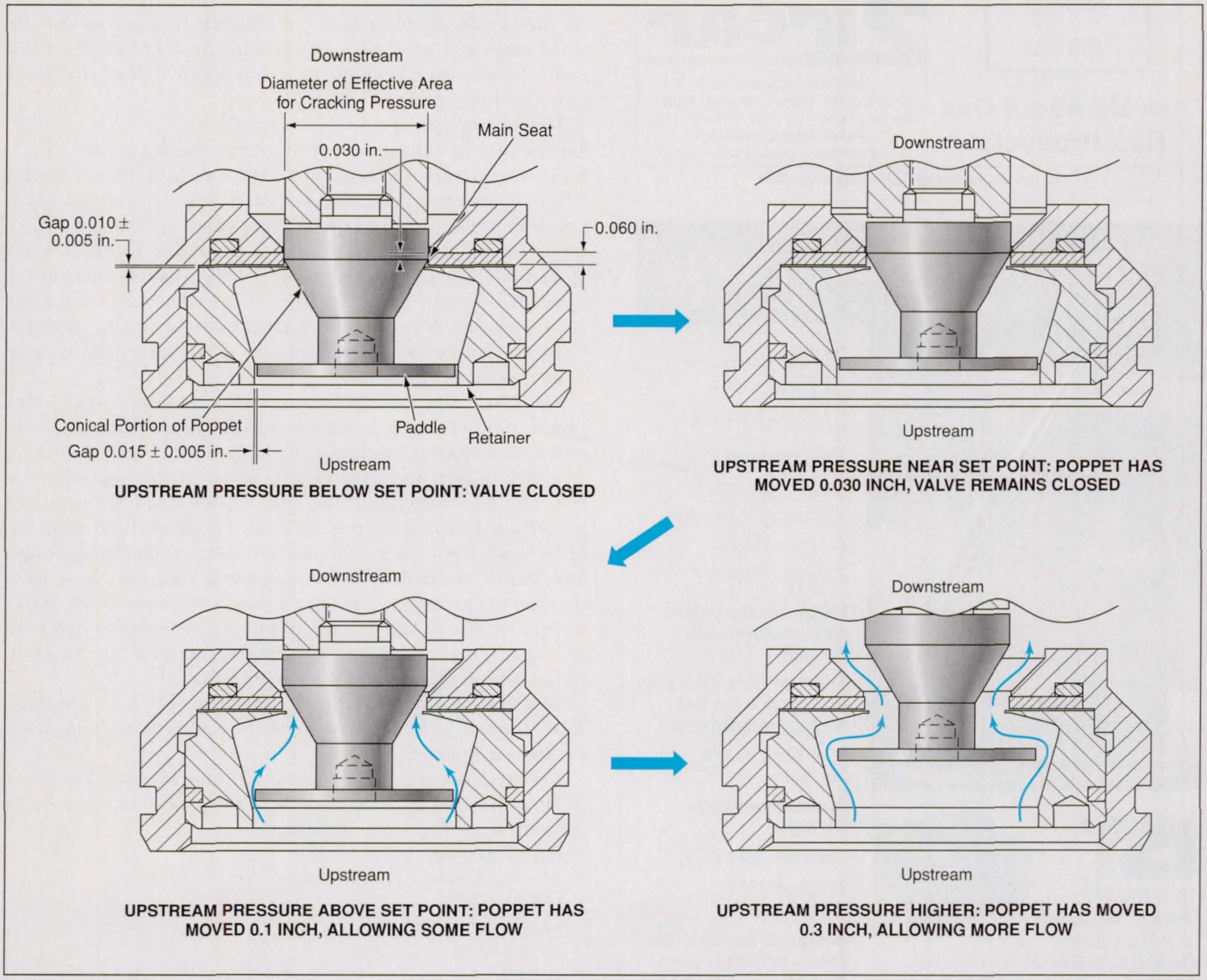
The risk of ignition in systems containing oxygen is reduced.

Stennis Space Center, Mississippi

Improved pressure-relief valves have been developed for systems that contain gases and liquids in a variety of pneumatic, hydraulic, and cryogenic applications. These valves could prove especially beneficial in both cryogenic and noncryogenic systems that contain oxygen. The improved valves are designed to suppress instabilities that shorten operational lifetimes and create hazards in the operation of older pressure-relief valves.

A typical older pressure-relief valve exhibits instability that can result in oscillation ("chatter"), which degrades the valve beyond the normal anticipated wear of parts. Oscillation can result in hard impact; in the presence of oxygen, hard impact can lead to ignition, with resultant catastrophic failure of the valve and possibly of the entire system. A valve of the present improved type is stable over its entire operational range from fully closed to fully open. It does not oscillate or generate hard impacts; instead, it opens and closes softly.

The key to stable, soft-opening/soft-closing operation is a concept of upstream control. A conventional "pop"-type pressure-relief valve is characterized as operating under downstream control: Once the valve has opened, the flow is controlled mainly by an effective cross-sectional area downstream of the valve seat. In a valve of the improved type, the flow-limiting cross sec-



This **Valve Operates Under Upstream Control** in the sense that the flow-constricting cross section is the annulus between the paddle and retainer, upstream from the annulus between the poppet cone and the main valve seat. The few dimensions shown here are typical only; the dimensions for a specific application are chosen, with the help of a mathematical model of valve dynamics, to obtain stable operation.

tion remains upstream of the valve seat at all times, and so the valve is said to operate under upstream control.

The figure illustrates the basic design and principle of operation of a valve of the improved type. As in a conventional relief valve, excessive upstream pressure opens the valve by lifting of a poppet from a seat in a valve body; however, the similarity with a conventional pressure-relief valve ends here. The poppet in the improved valve includes a conical portion and a paddle (essentially a disk) upstream of the conical portion. When the valve is closed and the upstream pressure is below the set point, the conical portion of the poppet engages about half the thickness of a main valve seat, forming a tight seal. In this condition, the paddle engages the wall of a cylindrical passage upstream of the main valve seat.

When the upstream pressure rises to approximately the set point, the poppet moves downstream a little, but the valve is not yet open; the conical portion of the poppet remains partly engaged with the main valve seat, while the paddle remains in the cylindrical passage in the retainer. As the pressure rises above the set point, the conical portion of the poppet moves out of the main valve seat and the paddle moves out of the cylindrical passage in the retainer. To ensure upstream control, the area of the annular opening between the main seat and the conical poppet surface must be made larger than the area of the annular opening between the paddle and the retainer; for this purpose, the angle of the conical inner valve-body surface immediately downstream of the main valve seat must be made greater than the angle of the conical inner valve-body surface immediately downstream of the cylindrical passage in the retainer.

The advantages of upstream control are:

- There are no adjustments other than the set point;
- There is a smooth transition from the fully closed to the fully open valve condition because there is minimal variation in density of fluid over a wide range of flow, and
- The upstream-control concept is amenable to mathematical modeling because the basic valve geometry (except for specific dimensions) is fixed. A user-friendly computer program based on a mathematical model of the valve dynamics can be used to design and select valves of this type for specific applications.

The improved valves offer several advantages over older pressure-relief valves, in addition to those mentioned above. Noise and wear are reduced through elimination of chatter. The risk of fire and explosion is reduced through elimination of hard impact, and the risk of uncontrolled venting of hazardous fluids is correspondingly reduced. Increased stability yields better performance, with wider operating ranges and better control. The basic valve design can be implemented in cartridge versions, so that it becomes unnecessary to remove entire valves from plumbing systems for overhaul or repair. The foregoing advantages translate to the additional advantage of lower life-cycle costs.

This work was done by Peter A. Tartaglia, Brian L. Magnone, Larry Rayhon, and Richard Molesworth of Marotta Scientific Corp. for **Stennis Space Center.**

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

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Refer to SSC-00073, volume and number of this NASA Tech Briefs *issue, and the page number.*

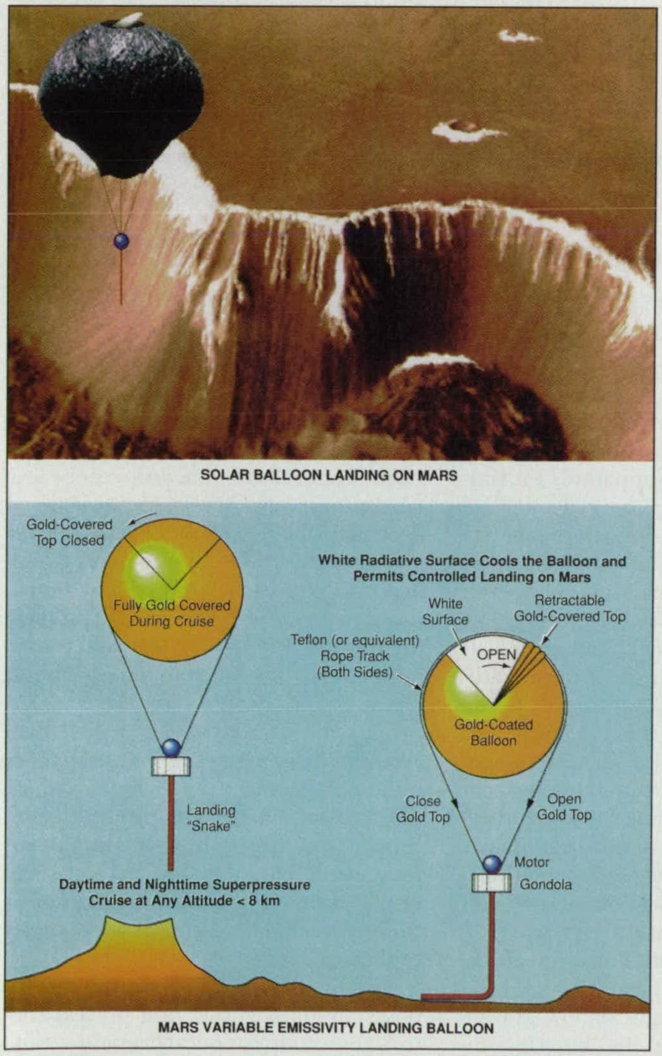
Two Techniques for Controlling Altitudes of Lifting Balloons

Multiple ascents and descents on long flights would be possible.

NASA's Jet Propulsion Laboratory, Pasadena, California

Two techniques have been proposed (see figure) for controlling the buoyancies and thus the altitudes of robotic lifting balloons (aerobots) that would carry scientific instruments for exploration of Mars. Buoyancy-control techniques other than these have been, variously, used on Earth and/or proposed for use in exploring planets other than Mars, but have been found inadequate for providing the requisite altitude control in the thin Martian atmosphere and at the low nighttime Martian surface temperature. The proposed techniques could also be used on Earth; for example, for carrying instruments to perform surveillance, monitor weather, or measure pollution.

The first proposed technique pertains to solar hot-air balloons. The concept of solar hot-air balloons is not new in itself; toy solar-heated balloons have been commercially available for years, and experiments on solar-heated aerobots for



SOLAR BALLOON LANDING ON MARS

MARS VARIABLE EMISSIVITY LANDING BALLOON

Two Techniques can be used to control the altitudes of robotic lifting balloons. A solar hot-air balloon uses vents (shown on top of the balloon) to control its buoyancy; another balloon uses variable-emissivity surface to control its buoyancy.

planetary exploration have been performed in recent years. The novel aspect of the proposed technique lies in the addition of controllable vents to the tops of the solar-heated balloons, similar in function to the controllable vents on commercial combustion-heated balloons. By letting out heated air from a balloon, one could reduce buoyancy to obtain descent. Conversely, one could close the vent so that as solar heating continued, buoyancy would increase, causing the balloon to ascend. In the case of remote and/or automatic control, the vent could be, for example, a motorized, balanced butterfly valve similar to a carburetor air valve. Of course, the balloon would have to land at night. Using this technique, multiple controlled soft landings and re-ascents have occurred in test flights in the Mojave Desert and off Southern California's Catalina Island.

Another unusual advantage of solar-heated balloons on Mars is the ability to use the balloon instead of retro-rockets, to soft-land payloads. The balloons not only cost much less, but they can increase useable landed payloads from under 10 percent (Pathfinder) to about 50 percent of total atmospheric entry mass.

The second proposed technique would be implemented on balloons filled with low-density gases (e.g., helium) at slight overpressures. This technique would provide altitude control during the night as well as the day. A balloon would be equipped with a variable-emissivity surface to control its internal temperature, and thus its buoyancy, by controlling the balance of thermal radiation among the balloon, the ground below, and the sky above. In the Mars case, for example, a balloon might be coated with gold, and equipped with a gold-coated top cover that could be retracted to expose a white top surface to the radiant cooling of deep space. Thus, retraction of the cover would cause buoyancy to decrease.

This work was done by Jack A. Jones of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*
NPO-20360

Hybrid Acoustic/Electrostatic Levitation Apparatus

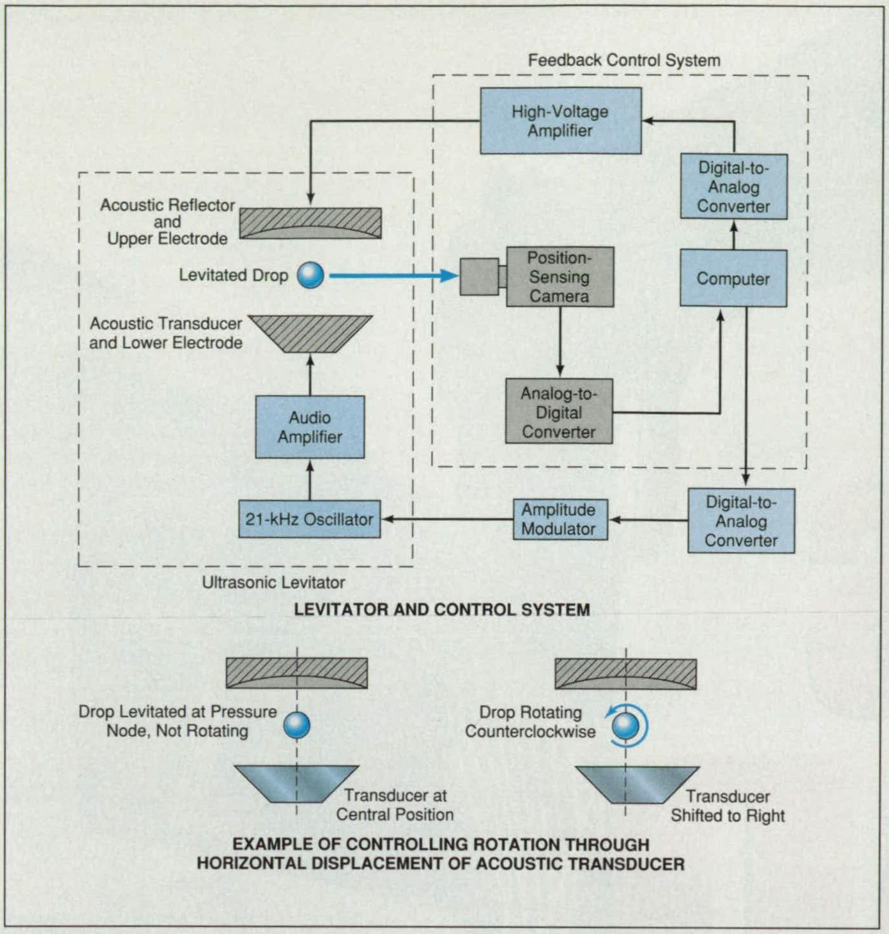
Conditions for experiments on growth of crystals, cells, and tissues can be highly controlled.

NASA's Jet Propulsion Laboratory, Pasadena, California

The figure schematically illustrates a developmental automated hybrid acoustic/electrostatic apparatus for levitating both electrically charged and electrically neutral liquid drops with sizes up to about 1 mm. The apparatus is particularly suitable for experiments on the growth of protein crystals from solution and on the growth of cells and tissues, all under controlled conditions. In addition to the obvious advantage of levitation for preventing the chemical and thermal contamination that accompanies contact between drops and external objects, this apparatus provides controllable rotation about a horizontal axis (for example, to reduce sedimentation). Moreover, the direction of rotation can be varied to randomize the effective direction of gravitation. Thus, on Earth, the apparatus is expected to provide some of the advantages of low gravitation for suppressing the buoyancy-induced flows that interfere with the growth of high-quality protein crystals and for reducing the adverse effects that gravitation exerts on some cell and tissue cultures.

An electrically neutral drop can be levitated acoustically. An electrically charged drop can be levitated electrostatically and/or acoustically. An important advantage of using both kinds of levitation is that if the acoustic field is used to produce rotation, the intensity of this field can be minimized, thereby minimizing disturbances in the drop. It has been conjectured that aerodynamic drag from acoustic streaming in the surrounding air is the physical mechanism through which the acoustic field exerts torque on the drop. The direction and amount of torque can be controlled by horizontal displacement of the acoustic transducer from its nominal central position under the acoustic reflector.

The apparatus allows optical access for observation, diagnosis, and process control. For example, optical diagnoses could be performed by imaging, light-scattering, and spectroscopic techniques. Temperature and humidity can be con-



This **Hybrid Acoustic/Electrostatic Levitation Apparatus** provides relatively quiescent levitation under controlled conditions, plus optical access for observation, diagnosis, and process control.

trolled and purity can be maintained by placing the apparatus in a closed chamber. A focused beam of light from a laser or other radiant source can be used for directional heating of a levitated drop.

This work was done by Eugene H. Trinh and Sang K. Chung of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

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Refer to NPO-20165, volume and number of this NASA Tech Briefs *issue, and the page number.*

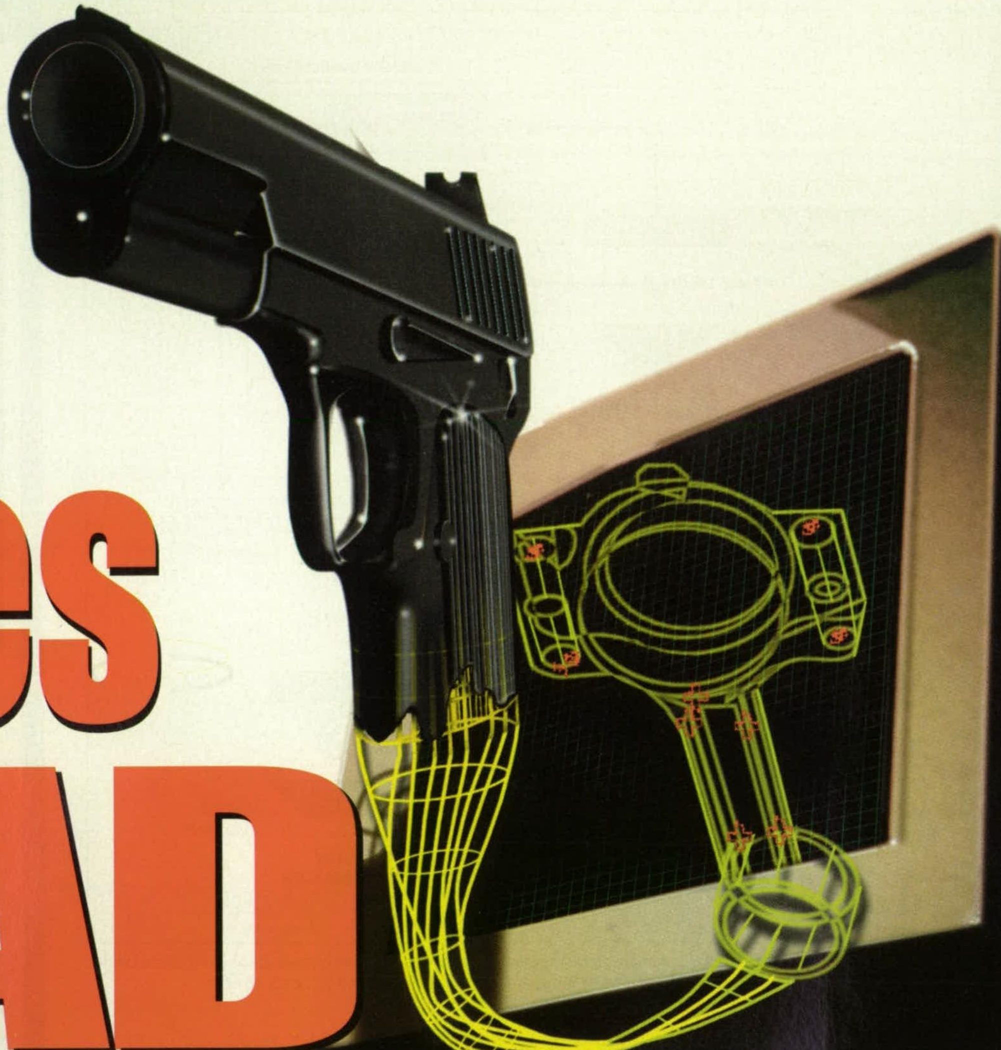
Using Genetic Algorithms in Spacecraft Vibration Control

Three developmental computer programs would provide for robust, reconfigurable, high-performance control.

American GNC Corporation, Chatsworth, CA

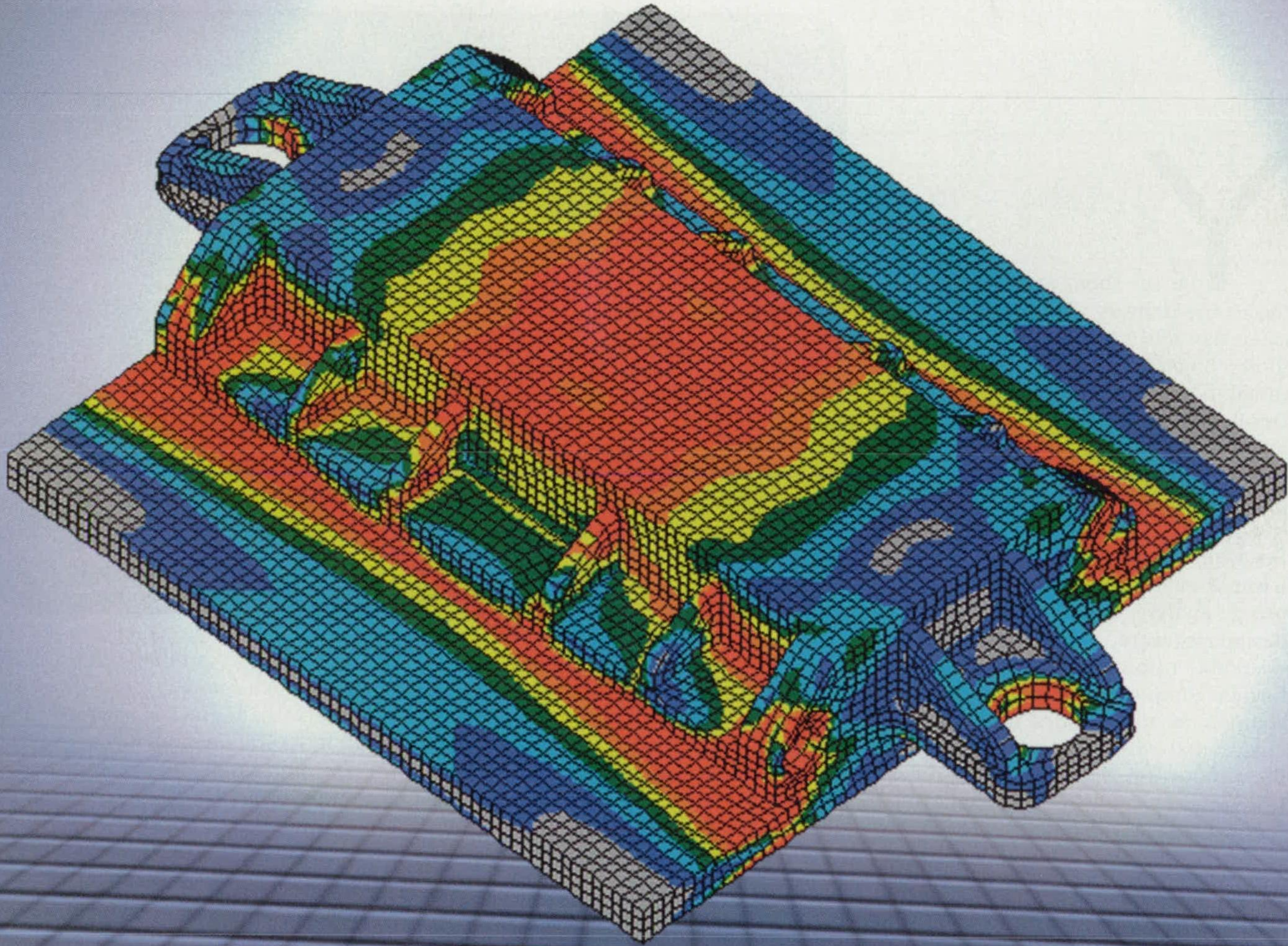
Three software products are being developed to help satisfy the needs of NASA and of private industry for reconfigurable active control systems to suppress vibrations in Reusable Launch Vehicles (RLVs) and other structures. These potentially highly marketable products are the following:

- The Integrated Structural Modeling and Intelligent Control Toolbox serves as a software environment for mathematical modeling, analysis, design, simulation, and implementation of genetic-algorithm-based "intelligent" control of vibrations in structures.



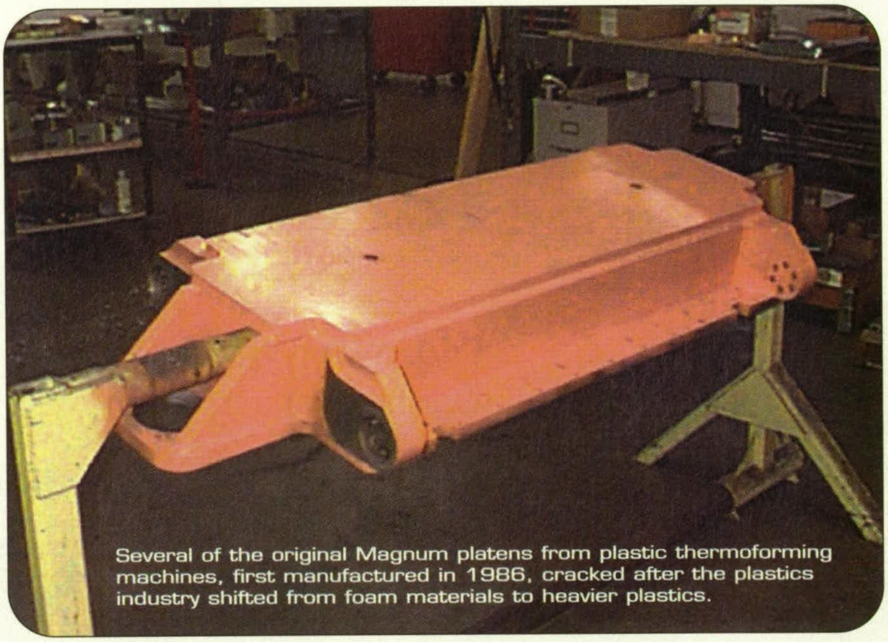
March 1999

Rapid Product Development



The platen shown here is a critical component of a web-fed foam thermoformer machine made by Irwin Reseaerch & Development. The company is using the software of Pittsburgh-based ALGOR, Inc. to interface finite element capabilities with the SolidWorks CAD system. See the feature on page 1b. (Image courtesy of ALGOR, Inc.)

FEA Software Speeds Plastic Product Design



Several of the original Magnum platens from plastic thermoforming machines, first manufactured in 1986, cracked after the plastics industry shifted from foam materials to heavier plastics.

You see them at the deli counter, in the delivery of take-out food, in cafeterias, and grocery stores — plastic food containers created by machines called thermoformers. Irwin Research & Development in Yakima, WA, manufacturer of the best-selling web-fed foam thermoformer in the U.S., is using software from Pittsburgh-based ALGOR, Inc. to interface finite element capabilities with the SolidWorks CAD software Irwin Research already was using. By using analysis in conjunction with design software, Irwin Research has been able to produce stronger thermoformer components that keep up with changes in the plastics industry, and ensure that consumer products roll off the production lines and into grocery stores and restaurants.

Irwin Research manufactures a variety of equipment for the plastics industry, specializing in equipment for thermoforming, a process by which flat sections of thermoplastic are molded into three-dimensional products. First, the thermoplastic passes through a heat tunnel, where it becomes soft and malleable. The thermoplastic may either be unwound from a roll (also called a web) or fed into the heat tunnel as a continuous, flat sheet. The plastic then passes into the former, where it is vacuum-stamped between two molds. The molded shape is then trimmed from the excess plastic, which is recycled to make new sections of plastic. Irwin's web-fed thermoformers use rolls of plastic to create small items such as cups, plates, and bowls. More than 700 of their machines operate in 26 countries.

Re-evaluating Essential Components

Since Irwin's Magnum Thermoformer was first manufactured in 1986, companies producing plastic items have moved from using foam materials to thicker types of plastic. Thicker plastics are sturdier, but these materials also require more pressure to vacuum-stamp shapes into the unformed plastic. Due to the increased pressure and fatigue, essential thermoformer components, called platens, developed cracks in several of the 60 Magnum thermoformers in operation.

A platen is used to transmit pressure from a press mechanism to a mold. Each thermoformer contains two assemblies consisting of a press, platen, and mold. A thermoformer with a cracked platen cannot safely be used. In addition, the quality of the product being produced may be compromised. Even with slight deformation, the platen will not be able to tightly seal the two molds together. Without a vacuum-tight seal between molds, the plastic product will not form correctly. For a company producing plastic products, a cracked platen could result in several weeks of down time and several thousand dollars for a new machine component, in addition to shipping and labor costs.

"At Irwin Research & Development, we strive to produce components that never fail, even after years of use," said Frederic Pasche, a mechanical engineer. "In 1986, the platen would have been prototype-tested. Now we use finite element analysis to determine where the highest stress will occur, and discover how to fabricate the platen to prevent future failures."

Based on the platen's geometry, Pasche created a finite element model with nearly 3,000 elements using ALGOR's Superdraw II. To speed processing without significantly affecting results, Pasche omitted small features such as mounting holes. An applied pressure of 250,000 pounds over the surface elements of the finite element

Frederic Pasche, mechanical engineer at Irwin Research & Development, created a finite element model of the original platen design in ALGOR (top). Linear stress analysis results (bottom) revealed high stresses coinciding with welded areas of the thermoformer component.

model reflected the rating of the press. Boundary conditions fixed the model on all four corners to replicate the platen's attachment to the bushings on which it is lowered and raised. Pasche used the material property values for steel from the Material Library included with ALGOR software.

Pasche then conducted a linear stress analysis and compared the Von Mises stresses to published yield stress for steel. He discovered that high stresses were occurring where sections of a platen had been welded together. "We set a goal to reduce the Von Mises stresses to below one-third of the yield stress," said Pasche.

Analyzing the CAD Model

To reinforce the platen, Pasche added thickness to the platen's geometry. First, he created a model of the platen in SolidWorks. Since performing the first platen analysis, Irwin Research had purchased ALGOR's Houdini software, which enabled Pasche to automatically create a finite element mesh from a SolidWorks IGES file. Houdini offers SolidWorks users three choices for solid FEA meshing of existing designs: tetrahedral, all-brick, or hybrid, with bricks on the surface and tetrahedra inside.

First, Houdini's Merlin Meshing Technology created a well-shaped surface mesh from the SolidWorks model. After the surface mesh was created, Houdini meshed a solid model from the surface in and put the highest quality elements on the surface. The surface is where loads and boundary conditions are applied and where stress levels tend to be the highest. This principle works with tetrahedral, brick, or hybrid models. Pasche used Houdini's brick meshing with Hexagen, with the standard option for a hybrid mesh. Again, Pasche omitted small features such as mounting holes to speed processing without significantly affecting results.

The model was analyzed using the same loading and initial conditions as used for the original model. Von Mises stress results revealed a much stronger platen. "The new design is approximately four times as strong as the original design," said Pasche. "The added strength will help to prevent fatigue failures." As an added measure, Irwin Research is considering fabricating the platen so that the location of the weld does not coincide with the areas of highest stress.

According to Pasche, "Performing finite element analysis helps with design. We no longer have to apply the trial-and-error method to prototypes that are expensive and time-consuming to produce."

Looking to the Future

Irwin Research & Development relies on finite element analysis because of the demanding time constraints of the consumer plastics industry. As the company prepares the Magnum platen for the 21st century demands of the industry, Pasche is including 21st century engineering software technology in his design cycle. The company plans to interface SolidWorks with ALGOR's Accupak/VE Mechanical Event Simulation software for Virtual Prototyping with Linear and Nonlinear Stress Analysis on projects in the future. Accupak/VE replaces physical testing with virtual testing by replicating mechanical events with a computer, helping to determine the behavior of a product in its real-world, worst-case scenario. Irwin Research & Development can predict motion and impact, perform stress analysis for each instant as the event unfolds, determine flexibility, intrinsically determine forces, handle complex shapes and nonlinear behavior, and test strength of materials, all with one package.

For more information on ALGOR software, contact the company at: 412-967-2700, or visit their web site at: http://www.algor.com

The platen was modeled in SolidWorks (top) and modifications were made to add strength to the design. Using ALGOR's Houdini software, a finite element mesh (center) was automatically created from a SolidWorks IGES file. Von Mises stress results (bottom) revealed that the new platen design is about four times stronger than the original design.

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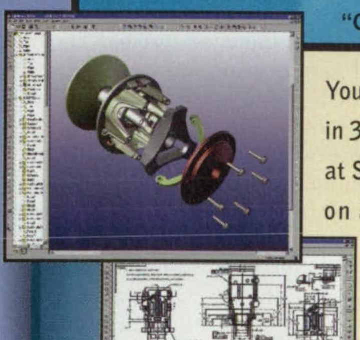

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New Frontiers in Mold Construction

High Conductivity Materials & Conformal Cooling Channels

Why are almost all production plastic injection molding core and cavity inserts made from steel? Steel is certainly not the hardest material. Steel is also definitely not the most corrosion-resistant material. And steel most assuredly is not the best conductor of heat. So why are production tools made from steel? The real answer is probably because that's the way they have been made for many years. People are used to working with steel molds. The results are predictable. However, there are now commercially available inserts that achieve: (1) shorter lead times, (2) faster cycle times, (3) enhanced productivity, (4) lower unit part cost, and (5) reduced part distortion.

A mold is effectively a thermodynamic engine. The analogy with an automobile engine is relevant. The well-known internal combustion engine sequence of "intake, compression, power, and exhaust" can be extended to plastic injection molding. In a motor vehicle, gasoline or diesel fuel is injected into the cylinder. In an injection mold, hot plastic is injected into the mold. In a gasoline engine, the fuel-air mixture is compressed to about 120 to 135 psi. In a diesel engine, the pressure reaches about 300 to 330 psi. In injection molding, the molten plastic typically is injected at pressures ranging from 5,000 psi to as high as 20,000 psi.

The power in a car is derived from chemical energy stored in the fuel, which is transformed into thermal energy during combustion, and ultimately converted, through the drive train, into kinetic energy. In injection molding, the thermal energy of the heated, molten plastic must be removed in order for the plastic to cool and transform into a solid.

Finally, in a car, the products of combustion must be exhausted from the engine. In a mold, the solidified plastic must be ejected from the press. In a passenger car, this cycle may occur from 800 to about 5,000 times per minute. In a Le Mans-winning race car, this cycle can occur as many as 17,000 times per minute.

In an injection mold, the entire thermodynamic cycle may occur as infrequently as 0.5 to perhaps 5 times per minute. The name of the game in auto racing is high engine revolutions per minute (RPM) coupled with high component reliability and success negotiating the race course without problems. The name of the game in plastic injection molding is really the same: high PPM (i.e. parts per minute), long tool life, and few distorted or rejected parts.

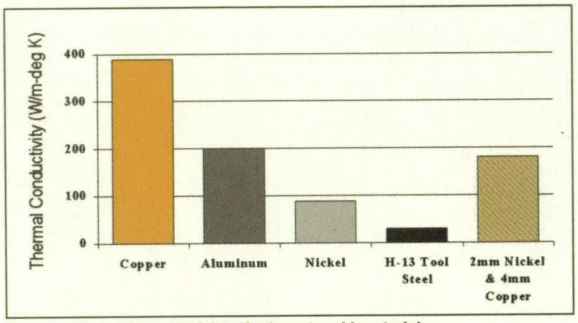


Figure 1. Thermal conductivity of relevant mold materials

While considerable efforts have gone into assuring that injection mold tools are functional and will provide long tool life, far less attention has been devoted to the fundamental issue of their thermal management.

High Thermal-Conductivity Materials

Figure 1 plots thermal conductivity for some relevant materials. Heat transferred from the plastic must be conducted through the material of the mold before it can be removed by coolant.

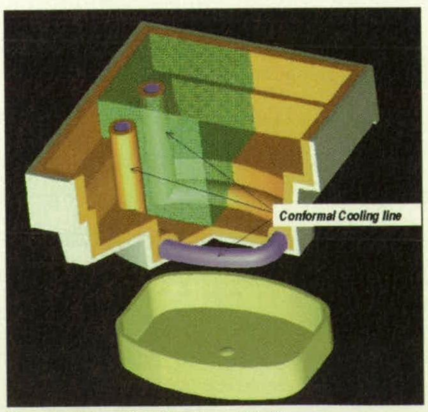


Figure 2. Example of Conformal Cooling

Thus, the thermal conductivity of the mold material is critical to mold thermal management. Inspection of this figure immediately reveals one of the basic problems with steel.

Here H-13 tool steel, having a thermal conductivity of 28 W/m°K, was chosen to be representative of the broad class of "tool steels." As a point of interest, 316 stainless steel is even less thermally conductive, at about 20 W/m°K.

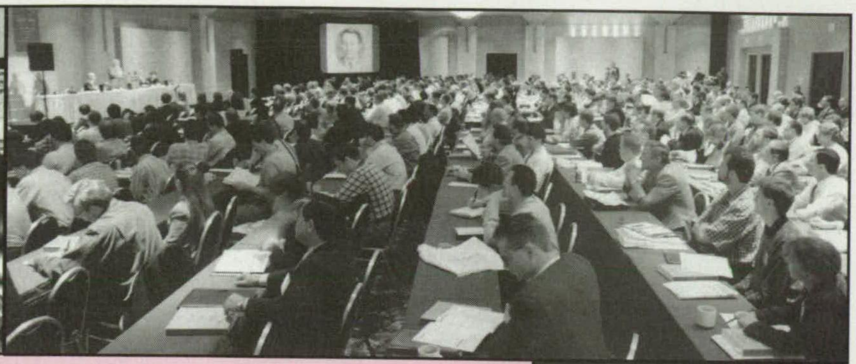
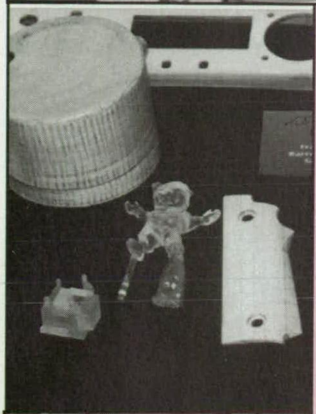
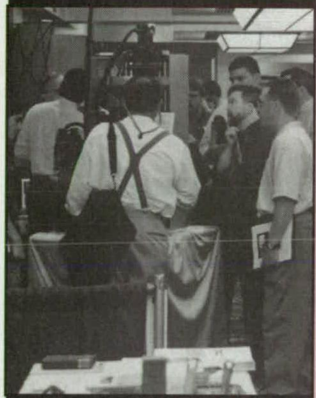
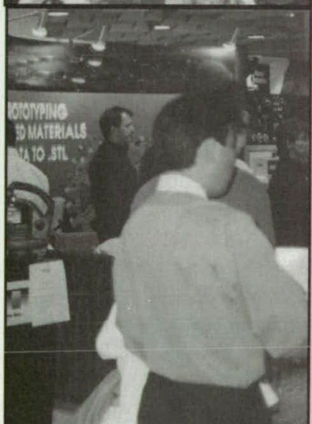
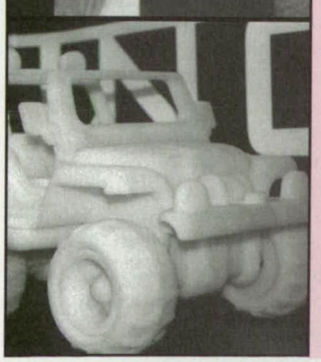
By comparison, copper at 390 W/m°K is about 13 times as conductive as H-13 steel, and almost 20 times as conductive as 316 stainless steel. While pure copper is too soft to provide long tool life at the active mold surface, it is a terrific material for thermal management.

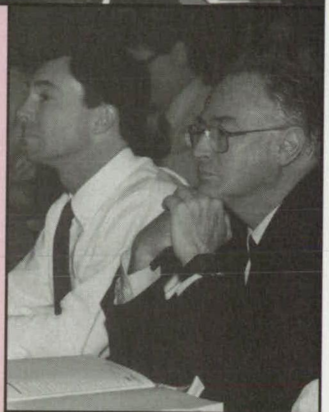
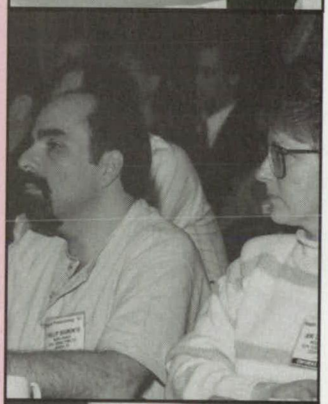
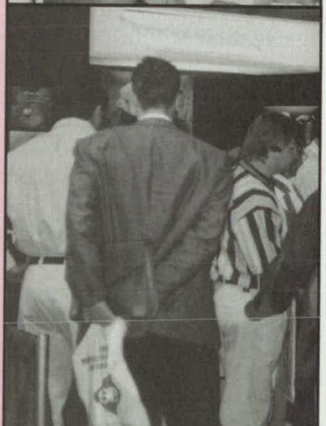
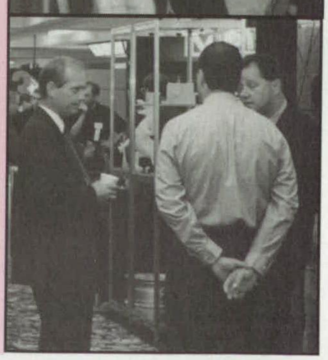
Next, aluminum possesses roughly half the thermal conductivity of copper, but is also too soft for long tool life. Nonetheless, as it is easily machined, aluminum is often used for prototype or bridge tooling applications, requiring a few hundred to perhaps as many as 50,000 parts injection-molded in the desired engineering thermoplastic. If glass-filled plastics are required, aluminum tool life will be further reduced.

On the other hand, nickel has a thermal conductivity of 88 W/m°K — more than triple that of H-13, and quadruple that of 316 stainless. Furthermore, nickel is very corrosion resistant, polishes well, is relatively hard, is abrasion resistant, can be textured, and provides excellent release characteristics.

Combining a 2-mm thick nickel shell at the active mold surface with a 4-mm thick copper thermal management layer that encapsulates the conformal cooling channels can provide dramatic benefits. The resulting Ni-Cu composite has an effective thermal conductivity some seven to nine times that of conventional steel tools, and is capable of generating production part quantities.



Conformal Cooling Channels

Conventional steel tools generally are CNC machined or electrical discharge machined (EDM) from a solid block of tool steel. Consequently, the cooling channels also must be drilled into solid steel. As a result, these channels essentially consist of a series of interconnecting straight segments,

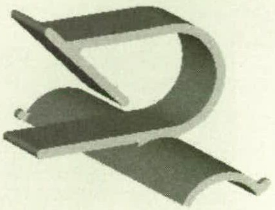


Figure 3. Automotive Harness Clip

each having a circular cross-section. This operation inevitably results in two important limitations.

First, because the cooling channels are "gun-barrel drilled," they cannot be made to conform to the curved shapes typical of injection molded plastic

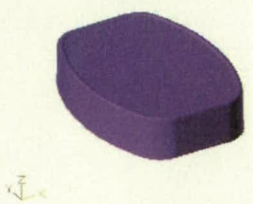


Figure 4: CAD model of a standard Vaseline jar cap

parts. The result is that some regions of the plastic are better cooled than other regions. The cooler plastic regions reach their solidification point earlier than the hotter regions. When the cooler regions solidify, they shrink. Somewhat later, when the hotter regions finally have cooled sufficiently to solidify, they also shrink.

However, the material shrinking last is attached to the plastic that had previously undergone shrinkage. This delayed shrinkage, occurring after attachment, behaves like a bi-metallic strip. The result is substantial internal stress and part distortion.

Thus, an important goal in plastic molding is to improve the uniformity of the mold temperature distribution over time. Finite Element Analysis (FEA) results show that conformal cooling channels (CCC), in conjunction with high conductivity mold materials, can provide major benefits. By positioning the CCC properly in x, y, and z space, it is possible to reduce mold temperature variance.

A key measure of mold performance is °Tmax, defined as the difference between the highest temperature of the plastic and the lowest temperature of the plastic at the instant the first portion of plastic begins to solidify and shrink. The lower the value of °Tmax, the more uniform the shrinkage and the smaller the resulting part distortion.

Figure 2 shows a conformal cooling channel used in the injection molding of a Vaseline jar cap for Chesebrough-Ponds. Note that the CCC transitions from a straight vertical section into an oval shape in the horizontal plane, and back to vertical again.

Machining a channel of this geometry in a solid block of steel would be impossible in a single piece, or prohibitively complex and expensive in multiple sections. However, when the active surface of the tool has been electroformed as a thin nickel shell, then positioning CCC behind the shell becomes straightforward.

Second, conventional drilled cooling channels (DCC) naturally have circular cross-sections. From Euclidean geometry, it is well known that of all possible two- dimensional shapes, circles have the smallest perimeter for a given enclosed cross-sectional area. Coolant flow rate (e.g. gallons per minute) is proportional to the enclosed cross-sectional area.

The heat transferred from the mold into the coolant is proportional to the perimeter of the channel. Thus, a cooling channel with a circular cross-section provides the minimum heat transfer for a given coolant flow rate. A range of CCC cross-sections should be explored to determine which shape provides the most effective cooling per unit coolant flow rate.

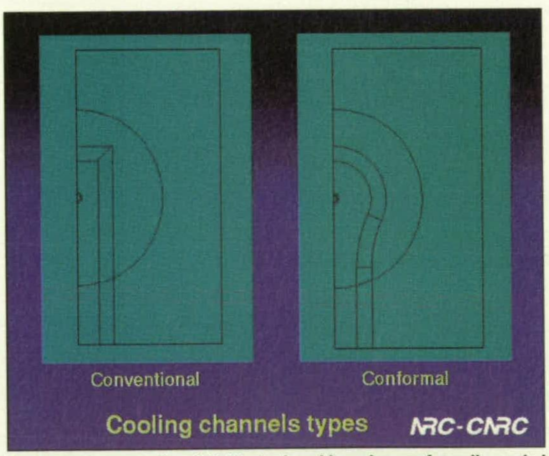


Figure 5: A conventional H-13 steel mold, and a conformally cooled Ni-Cu mold

Case Studies

Figure 3 shows an automotive wire harness clip. This part was injection molded in nylon using two different molds. First, ExpressTool Inc., Warwick, RI, built electroformed Ni-Cu inserts with CCC for United Technologies Research Center, East Hartford, CT. Concurrently, a conventional H-13 steel production mold at United Technology Automotive (UTA), Dearborn, MI, also was used to produce the same wire harness clip. The clip is 60 mm long (2.38 inches) by 35 mm wide (1.38 inches) by 30 mm high (1.18 inches). The same mold base was used in both cases.

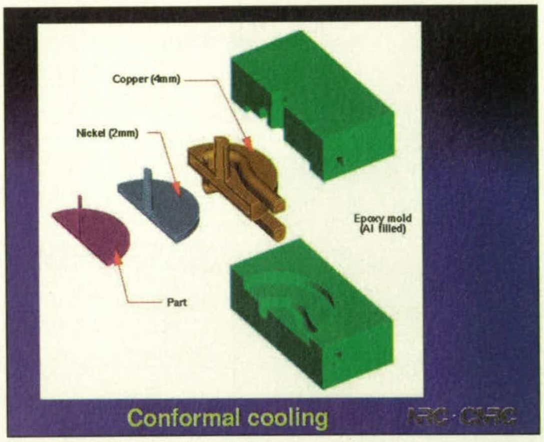


Figure 6: Model of the Ni-Cu Mold

Two separate cooling channels were dictated by the wire harness geometry. One CCC was used primarily to cool the central regions of the part, while the second channel cooled the peripheral regions. Although the geometry of these channels may seem complicated, it is important to note that these CCC are fabricated easily and placed behind the nickel shell prior to copper electroforming. In this way, the cooling channels are completely encapsulated in highly conductive electroformed copper. The heat from the hot plastic can flow through the nickel shell, through the copper thermal management layer, and directly into the conformal cooling channel, where it is transferred away by convection.

After set-up, thermal stabilization of the tool, and optimization of mold parameters, the measured cycle time for the production H-13 mold at UTA was 21 seconds. This corresponds to 3600/21 = 171 parts per hour, assuming uninterrupted operation of the injection molding press.

Again, after set-up, stabilization of the tool, and optimizing the mold parame-

ters, the cycle time for the electroformed Ni-Cu CCC mold was 12 seconds, corresponding to 3600 /12 = 300 parts per hour, again assuming uninterrupted operation of the injection molding press. Note that 300 /171 = 1.75, or a 75% increase in mold productivity as a consequence of utilizing an electroformed nickel-copper tool with conformal cooling channels.

In the second case study, Figure 4 shows a CAD model of a standard Vaseline jar cap injection molded in high impact styrene for Chesebrough-Ponds. The performance of an existing H-13 steel mold built with conventional DCC was compared to the performance of an electroformed Ni-Cu tool with encapsulated CCC.

After set-up, thermal stabilization of the tool, and optimization of the molding parameters, the measured cycle time for the production H-13/DCC mold was 15 seconds, corresponding to 3600/15 = 240 parts per hour, assuming uninterrupted operation of the molding press.

Again, after set-up, thermal stabilization of the tool, and optimizing mold parameters, the cycle time for the electroformed Ni-Cu/CCC mold was 9 seconds, corresponding to 3600/9 = 400 parts per hour, assuming uninterrupted operation of the molding press. Note that 400/240 = 1.67, or a 67% increase in mold productivity when using an electroformed nickel-copper tool with conformal cooling channels.

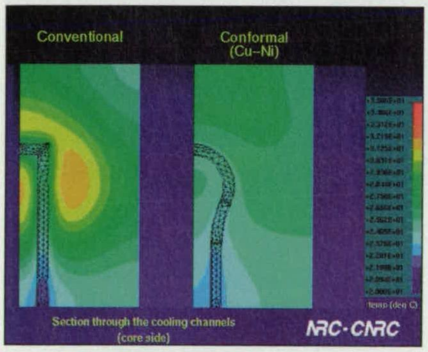


Figure 7: Core temperature distributions

It is clear from these two case studies that the reduction in mold cycle time, and the consequent increase in productivity for Ni-Cu/CCC molds relative to conventional H-13/DCC steel molds is dramatic. FEA results provide an explanation for these substantial reductions in cycle time, as well as major improvements in mold temperature uniformity .

Finite Element Analysis

To gain a better understanding of the fundamental phenomena occurring within an injection mold, ExpressTool began working with the FEA/Process Modelling and Optimization Group at the National Research Council (NRC), Boucherville, Quebec, Canada, under the direction of Georges Salloum.

The temperature distributions presented here were developed through a collaboration with Michel Perrault of NRC. The calculations were based upon the latest version of the NRC FEA code. Starting from a CAD model of a specific part, Perrault modeled the geometry of the mold, as well as the geometry of both the DCC and CCC cases, respectively. Finally, he used representative thermal and mechanical properties for H-13 steel, as well as those for electroformed nickel and electroformed copper where relevant.

If one cannot understand a simple problem, the chance of understanding a related but more complicated problem is greatly diminished. Thus, the part selected for the initial FEA thermal analysis is a simple circular disk, 3 inches in diameter, and 0.1 inch thick. The part geometry, while flat, has a round shape typical of many injection molded parts, and also has little intrinsic stiffness, as there are no supporting ribs or gussets.

Figure 5 shows a top view of the two cases evaluated by FEA. The first case

corresponds to an H-13 steel tool with DCC, shown on the left. The second case corresponds to an electroformed Ni-Cu tool with CCC, shown on the right.

For this case, the CCC geometry looks something like a keyhole when viewed from above. While in principle the CCC could have arbitrary cross-sectional shape, the channel cross-sections were assumed to be circular.

Figure 6 shows the model of the Ni-Cu tool developed at NRC that formed the basis of the ensuing FEA analysis. Specifically, the part was assumed to be gated in the center, the nickel shell was assumed to be 2mm (0.080 inch) thick, the copper thermal management layer was assumed to be 4mm (0.160 inch) thick, the copper was assumed to fully encapsulate the CCC, and the tool was assumed to be backed with aluminum filled epoxy having a thermal conductivity of 2 W/m°K. Compared with a thermal conductivity of 88 W/m°K for nickel and 390 W/m°K for copper, a value of only 2 W/m°K for the mold backing material effectively treats the latter as an insulator.

Figure 7 is a pseudo-color FEA image of the distribution of temperature throughout the core sides of the two tools for: (1) the conventional H-13 tool with DCC shown on the left; and (2) the Ni-Cu tool with CCC shown on the right. The difference in the two temperature distributions is dramatic. The H-13 tool with DCC shows a hot spot to the left of the cooling channel (near the sprue) and another to the right of the channel. Conversely, the Ni-Cu tool with CCC shows an almost isothermal temperature distribution.

The value of °Tmax for the H-13/DCC case is 12.5°C. In contrast, the value of °Tmax for the nickel/copper tool with CCC is only 2°C. Obviously, the combination of high thermal conductivity materials and conformal cooling channels significantly reduces mold temperature variations.

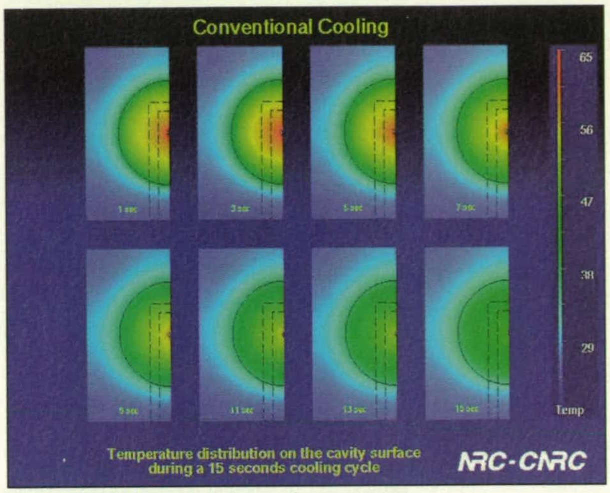


Figure 9: H-13 / DCC temperature vs. time

Figure 8 is another pseudo-color image of the temperature distribution on the cavity side of the tools for: (1) the conventional H-13 tool with DCC on the left; and (2) the Ni-Cu tool with CCC on the right. Here the effect is even more dramatic than on the core side. The value of °Tmax for the H-13/DCC tool is 18.6°C. The value for the nickel/copper tool is only 1.9°C, or essentially an order of magnitude reduction in mold temperature variance.

Figure 9 shows the pseudo-color temperature distribution for the cavity surface of the H-13/DCC tool at two-second intervals from 1 to 15 seconds after plastic injection. These images illustrate the cooling of the tool over time. Figure 10 shows the same information for the Ni-Cu/CCC tool.

It is evident from inspection of these two figures that the cooling rates for the Ni-Cu/CCC tool are much faster than for the H-13/DCC tool. In fact, the temperatures throughout the Ni-Cu/CCC tool only three seconds after injection already are lower than the corresponding temperatures for the H-13/DCC tool after 15 seconds.

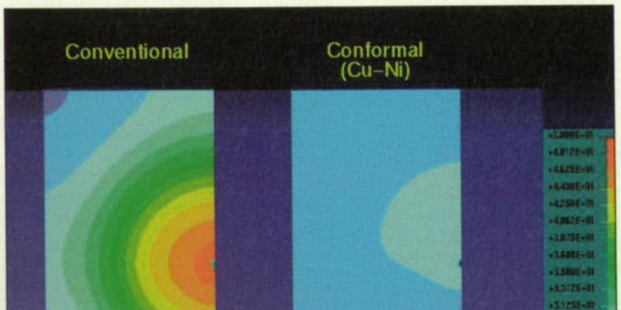


Figure 8: Cavity temperature distributions

This data begins to explain the reasons behind the extraordinary productivity improvements noted in the two case studies presented earlier. In fact, the only reason the productivity gains are not even bigger is that the cycle time includes not only the cooling time, but also the times to: (1) close the press; (2) inject the plastic; (3) pack the plastic; (4) open the mold; and (5) eject the part. These five time intervals are not affected by the thermal conductivity of the mold, or CCC vs. DCC.

Thus, the reported improvements in productivity are only realized through the reduction of the cooling time. However, since the cooling time typically is the largest component of the overall cycle time, the benefits of reduced cooling time can be, and are, quite significant.

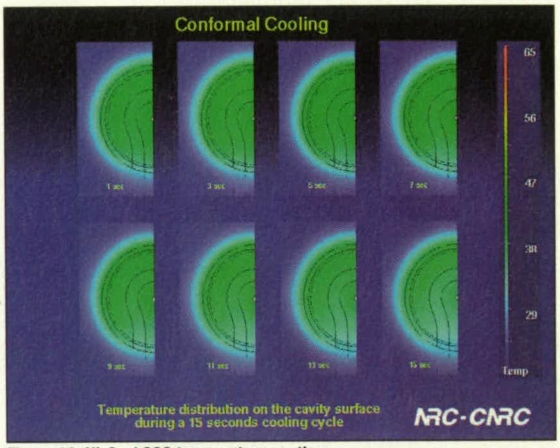


Figure 10: Ni-Cu / CCC temperature vs. time

In conclusion, nickel/copper mold materials, using conformal cooling channels, produce more uniform mold temperature distributions. The value of °Tmax was an order of magnitude lower for the Ni-Cu/CCC than the corresponding value for an H-13/DCC.

Nickel/copper mold materials, coupled with the use of conformal cooling channels, also result in much more rapid cooling times, which in turn lead to much shorter overall mold cycle times.

The nickel-copper/CCC molds resulted in productivity improvements of 75% and 67%, respectively, relative to conventional H-13 tools with DCC .

For more information, contact the author of this article, Dr. Paul F. Jacobs, Vice President of Technology, ExpressTool, 300 Metro Center Blvd., Warwick, RI 02886; Tel: 401-737-7900; Fax: 401-737-8223; pjacobs@expresstool.com.

Injection-Molding Thermoplastic Parts from Composite Board

A new material increases mold and part accuracy in rapid prototyping.

Johnson Controls Inc., Automotive Interiors Division, Holland, Michigan, and Ciba Specialty Chemicals, East Lansing, Michigan

Prototyping is today the only way to effectively validate many new design concepts. Because manufacturers emphasize consolidation of components to reduce costs, there has been an overall increase in part complexity. Although computer models can indicate the theoretical success of a design, it is through the generation of solid models and prototypes that engineering tests and marketing feedback can be obtained.

One widely used prototyping method uses rapid modeling and tooling techniques to form cast injection molds for running components from production thermoplastics. The benefit of forming production-intent prototypes from the end-product material is that the parts feature the same properties, such as weight, density, feel, and flexibility, as the final part. But a drawback has been in the moldmaking products and processes used for rapid tooling.

The Automotive Interiors Division (formerly Prince Corp.) of Johnson Controls, Inc. (JCI) initiated a research program with Ciba Specialty Chemicals to develop a tooling material that could produce highly accurate core and cavity injection molds using fewer construction steps. The program led to the subject new composite board.

Among the goals and objectives of the program were:

- Machine a mold that could withstand injection molding pressures and temperatures used for engineering thermoplastics such as polypropylene, acrylonitrile-butadiene-styrene copolymer (ABS), and polycarbonate. Specifically, the moldmaking material has to exhibit good compressive and flexural strengths, in excess of about 8000 psi, and must be able to withstand the required temperatures, approximately 350-600°F.
- Produce an injection mold via high-speed machining at substantial feed rates.
- Develop a tool that could hold part accuracy to ±0.005 inch.
- Injection mold up to 250 thermoplastic production-representative parts.
- Attain a machined surface finish equal to or better than that produced with electrodes.
- Develop a surface that could mold thermoplastic parts without secondary surface treatments.
- Create a surface that could be polished or textured.

The new composite board developed by JCI and Ciba meets each of these criteria, with the exception that machined surfaces do require secondary treatment.

Process	Materials		
	Composite	Electrode Carbon	QC-7 Alum
CNC Machining	2.25	2.25	3.0
CNC EDM	—	—	8.0
Finishing	—	—	1.0
Total	**2.25**	**2.25**	**12.0**

Hours to Machine Bracket Cap Molds

Further development involved designing molds using a computer-aided design software package that analyzed the configuration of a simple test part. The computer program was then used to aid in the creation of a reverse image of the part, incorporating mold features such as parting line, venting, sprue and runners, and ejectors.

When mold design was completed, preparations for high-speed CNC machining were made, including setup parameters as defined in cutter pathing for part geometry. During initial test runs, the preferred cutting tool for use on the composite board was a solid carbide ball-nosed end mill with one-and-one-half degree taper per side for draft. Spindle speed for machining the board was generally 6000 to 10,000 revolutions per minute (RPM) for roughing and 15,000 RPM for finishing. Cutter wear was negligible.

To enhance the performance of the resulting composite board tool, a pocketed steel support structure was attached to the core and cavity molds. This frame was used to produce additional mold strength, to help the tool withstand the force and stress of injection molding, and to generate a greater number of parts without degrading.

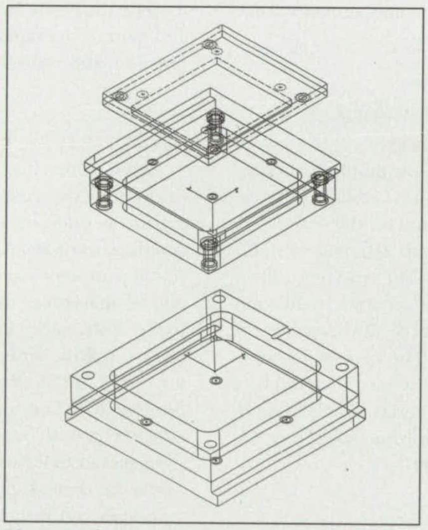


Diagram of visor backbone mold insert.

When the workability of the composite board for initial injection molds was verified, a series of different thermoplastic parts was formed to confirm mold performance under a variety of conditions. Three of the prototype parts Prince selected were an automobile visor bracket cap, a visor track extender, and a visor backbone.

The bracket cap was deemed a realistic candidate to produce a functional part in molds machined from the new composite board. To test the machinability and molding capabilities of the composite board, core and cavity mold inserts were machined from the new product as well as from conventional electrode carbon and aluminum moldmaking materials. The table demonstrates the significant time savings that accrued from machining the bracket cap mold from the board versus aluminum. Nonstructured testing confirmed that parts from the carbon and composite tools were virtually identical.

The third part tested during the research program was a visor backbone, an aesthetic structural member for the foam visor core and mountings for other functional items. The design of the part was ideal for demonstrating the strengths of the new tooling board because it featured deep ribs, as shown in the figure, that required significantly more moldmaking operations for aluminum tools, including more finish cutting, electrode prep, electrical discharge machining (EDM), and final polishing. With the composite board all of the required details were cut in one setup, saving almost 50 hours over aluminum molds and also increasing core and cavity accuracy. Preliminary dimensional testing indicated that the prototypes run in the composite molds were virtually identical to the parts produced on the aluminum inserts.

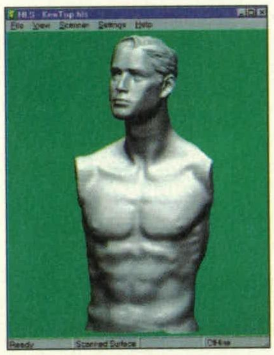
For more information on the new composite board, contact the author of the SME paper based on the above material, Ken Filipiak, lead tool engineer/tool room manager at JCI; (616) 394-6432; fax: (616) 394-6464, or Mahesh Kotnis of Ciba Specialty Chemicals.

NEW PRODUCTS

Free-Form Surfacing Technology

Surfacer Version 8.5 surface modeling software from Imageware Corp., Ann Arbor, MI, allows users to go seamlessly from rough concept surfaces, to Class 1 surfaces, through tooling design. Flexible surface creation supports Bezier and NURBS patch layout, and provides the ability to choose a preferred surfacing methodology based on curve network, direct manipulation, or a hybrid methodology. Other features include intuitive, process-driven surface creation tools that deliver savings in overall product development cycle time; interactive surface modification tools to facilitate rapid exploration of multiple design iterations; and real-time diagnostics. The software provides seamless integration to standard CAD systems. **Circle No. 787**

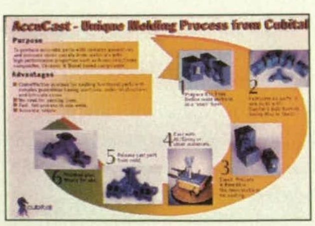
Handheld Laser Scanner



Polhemus, Colchester, VT, offers the Handheld Laser Scanner (HLS) for converting physical models to digital models. The system allows engineers to examine and modify conceptual design models for rapid prototyping and manufacturing of parts. Measurements are made by sweeping the HLS wand over the desired object in a manner similar to spray painting. The system follows the movement of the wand, relays the coordinates to the software utility, and provides an instant digitized image of the object on a computer screen. The 3D data then can be saved in industry-standard formats such as IGES, ASCII, and VRML for use and re-design. The system is designed to scan non-metallic opaque objects. Movable objects may be scanned by attaching a second Tracker Receiver to the object. **Circle No. 788**

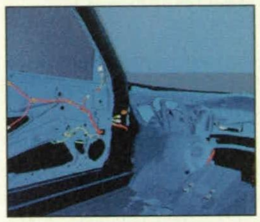
Surfacing/Reverse Engineering Tool

Alias|Wavefront, a subsidiary of Silicon Graphics, Toronto, ON, Canada, has introduced SurfaceStudio™, which provides modeling and reverse engineering tools, real-time diagnostic tools, and scan data processing technology. Designed for surface modeling and reverse engineering, the software features new user interface panels designed to support the technical surfacing workflow. Cloud Processing and Manipulation allows large cloud datasets to be read, displayed, manipulated, modified, and processed. Reverse Engineering Tools include sectioning, curve fitting, surfacing, and deviation measurement tools. Real-Time Diagnostic tools allow viewing of deviation from specified criteria, surface curvature, reflection lines, highlight lines, and cross-sections. **Circle No. 791**



High-Performance Material Parts

AccuCast, a lost mold technology application from Cubital America, Troy, MI, is based on the company's Solid Ground Curing (SGC) methodology. The process allows the creation of accurate mold tools for casting. Molds are divided and built from several sections; each module may contain complex cavities and undercuts. The process incorporates the Wax In Shell (WIS) build style, in which the wax enclosed by a photopolymer shell serves as the final building material. The WIS modules are disassembled by removing the thin photopolymer shell from the mold surface and dissolving the wax. **Circle No. 790**



Model Visualization Software

VisionShare interactive digital mock-up software from InterData Access, Westchester, IL, supports product design and manufacturing processes by integrating concurrent engineering technologies. The program offers collaborative viewing and analysis of complex designs, configuration management, measurement, interference analysis, and viewing of CAD/CAM designs. Design data from multiple CAD applications can be combined and viewed as an assembly. The user can then check possible collision points, verify fit and function, and measure distances within components or across the design. Other features include real-time conferencing/whiteboarding capabilities, PDM system integration, and bi-directional CAD interfaces, allowing problems found in the design to be highlighted in the native CAD application. **Circle No. 792**

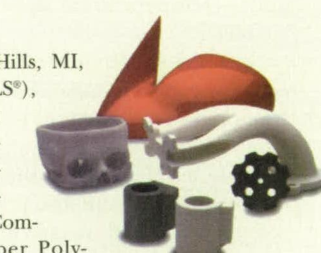
New Parts Materials

Ciba Specialty Chemicals, East Lansing, MI, has introduced Parts-In-Minutes® polyurethanes and Ren Shape® boards for machining of foundry patterns and fixtures. The Parts-In-Minutes line provides for demolding of thermoplastic-like parts in less than 30 minutes. The materials offer high heat resistance, impact and flexural strength, and UL 94 V-O flame retardance. New materials include RP 6461 R/H polyurethane with heat resistance to 309°F; RP 6473 Si silicone for casting clear, flexible molds; and four soft elastomers. The Ren Shape 5169 is a red-colored board for machining foundry tools, including patterns and core boxes. Ren Shape 472 is a low-density material with flexural, tensile, and compressive strength, and a low coefficient of thermal expansion. **Circle No. 793**

Manufacturing Optimization

Signature Control Systems, Denver, CO, has released SmartCure™ Version 3.0 manufacturing software that integrates Supervisory, Control and Data Acquisition (SCADA); Human Machine Interface (HMI); and an expert system module for intelligent control. The program's historical database can be queried by date, customer, operator, part number, serial number, and material type. The software optimizes the manufacturing cycle times of engineered thermoset, thermoplastic, and elastomeric materials. Running in Windows NT, the software allows for auto and manual operation of a variety of processes, including injection, compression, and resin transfer molding. **Circle No. 789**

3D Prototype Parts



Rapid Prototype Co., Auburn Hills, MI, offers Selective Laser Sintering (SLS®), a process that converts parts from two-dimensional CAD data to functional prototypes made from a variety of materials, including Duraform™ Polyamide, Protoform™— Composite nylon, fine nylon™, Cooper Polyamide™, DTM Polycarbonate, and DuPont Somos® 201 Thermoplastic Elastomer. Using the SLS process, prototypes can bolt together; accept fasteners and self-tapping screws; hold motors, circuit boards, batteries, and other components; be drilled, painted, or machined; and form living hinges that can be flexed without separating. They also can be snapped together and absorb stress without breaking. **Circle No. 794**

• The Intelligent Distributed Structural Control Node is a real-time software prototype of a distributed control system that employs distributed fuzzy-logic structural controllers and a fuzzy neural reconfiguration strategy.
• The Distributed Health Monitoring and Decision-Making Integration System is a software system for genetic-algorithm-based, decentralized, parallelized fault detection and isolation (FDI) and reconfiguration.

The need for these products arises from the following considerations: Active control for suppressing vibrations in spacecraft is a topic of considerable importance, especially lately, given the advent of Reusable Launch Vehicles (RLVs). One of the difficulties in designing capable controllers for space structures lies in the inability to obtain or to test accurate mathematical models of their dynamics, including submodels of vibration modes, prior to launching the structures into outer space. Thus, in designing a vibration controller for a space structure, it becomes a requirement to provide robustness against all possible uncertainties. Ideally, the structure vibration controller should be able to both characterize the dynamics of the structure and modify its dynamical model after launch, thereby affording both superior robustness and excellent performance.

Also, the stability of individual components on RLVs is an issue of grave concern. Stiffening these components often entails adding undesirable weight. The characterization of these components and the attenuation of their accelerations, by use of a "smart" active vibration-control system, are of the utmost importance in an effort to attain the all-consuming goal of minimizing RLV weight.

Other important issues related directly to the vibration-control issue include the need to protect expensive, fragile payloads, to release them into their orbits as accurately as possible. An accurate and efficient placement and/or pointing of a payload to be released into orbit from an RLV an application of enormous commercial value.

The three software products mentioned above take advantage of active vibration control methods and equipment, including "smart" piezoelectric sensors, actuators, and sensor/actuator units. Genetic algorithms serve as means for optimization and learning. These three products implement genetic-algorithm-based techniques of "intelligent," reconfigurable active vibration control developed by American GNC Corp.

Potential applications for the three software products include attenuation of accelerations for space-based experimentation in combustion and growth of crystals, enhancing spacecraft and aircraft ride qualities, extending the lives of aircraft and spacecraft by minimizing the damage wrought by structural vehicle vibrations, and extending the lives of airplanes by minimizing loads on wing roots. Also, these products and the associated techniques can be used for high-precision pointing and active control of vibrations of civilian and military flexible structural systems, including optomechanical systems, aerospace structures, weapon systems, positioning machines, and robotics.

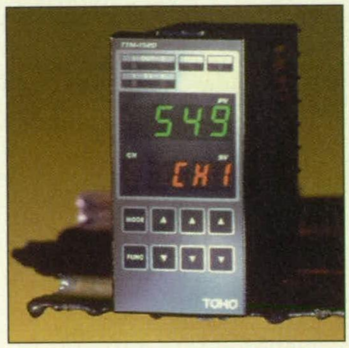
This work has been and will be undertaken by the **American GNC Corporation,** *9131 Mason Avenue, Chatsworth, CA 91311, an SBA 8(a) certified Small Disadvantaged Business concern, as part of a NASA Small Business Innovation Research (SBIR) project monitored by* **Marshall Space Flight Center.** *The NASA SBIR Contract Number is NAS8-98101; Topic: 97-1 08.01; Topic Title: Launch Vehicle Technologies. For further information, contact Dr. Ching-Fang Lin, American GNC Corporation, at tel: (818) 407-0092, fax: (818) 407-0093, or e-mail: cflin@americangnc.com.*
SBIR0006

Special Coverage: Industrial Controls

The CN3101 Series programmable 1/4 DIN high/low **limit controller** from OMEGA Engineering, Stamford, CT, is UL-listed and FM-approved. With user-programmable inputs and high/low limit features, it is adaptable to most limit control applications, and can be reconfigured as needed. Limit control features include a total time over/under setpoint display and peak (maximum or minimum) process variable display.

The system's features allow users to determine if process damage has occurred, and can help in analyzing the cause if a shutdown has occurred. The CN3200-SOFT communications package allows the controller to be programmed and configured, and to have the operation monitored remotely via computer. Several controllers can be connected on the same communications line using the RS-485 standard, or through modems using an RS-232C connection.

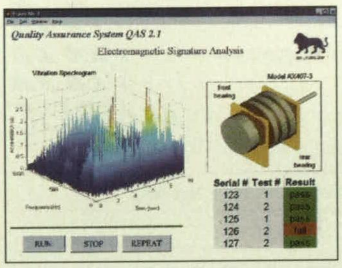
For More Information Circle No. 713



Total Temperature Instrumentation, Williston, VT, offers the TTM 1520 dual-channel 1/8 DIN **controller** that includes RS-485 communications, several event outputs, and a variety of analog transmission outputs. An optional 24V AC/DC power supply also is available. The two-channel control setting allows independent control of two channels for both input and output.

With Cascade Control, two inputs and one output are applied, Positioning Proportional Control provides input by feedback resistance, and Remote Control by remote SV input. The unit accepts thermocouple, RTD, thermistor, and DC current/voltage. Control output options include relay, SSR drive voltage, 1-5V, 0-10V, and 4-20mA.

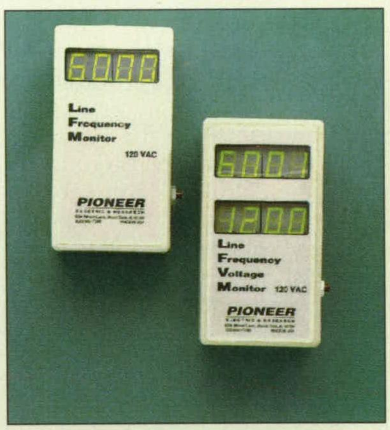
For More Information Circle No. 710



The RH Lyon **quality assurance system** from RH Lyon Corp., Cambridge, MA, predicts product noise and sound quality by using process measurements to identify defects and diagnose their cause. The system features a custom-engineered manipulate, load, and drive system with sensors and actuators, and a workstation that performs diagnostic signal analysis of process variables such as sound and vibration, current, voltage, pressure, and flow.

The system provides intelligent monitoring that can store data, output to a manufacturing network, activate a classification system to designate a product for routing, and perform other functions. The system identifies the features of an objectionable sound, figures out how to detect those features through signal analysis, and how to prevent shipping of the product.

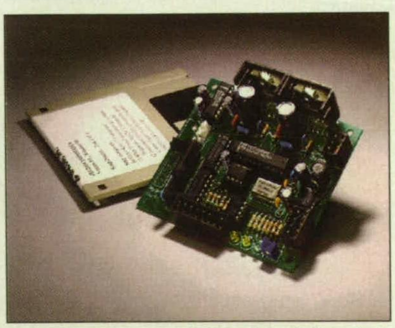
For More Information Circle No. 711



Pioneer Electric & Research, Wood Dale, IL, has introduced AC **line monitors** for troubleshooting industrial equipment. The monitors detect problems in AC line power, 120/240-volt step-up/step-down transformers, back-up generators, and power supplies. They instantly indicate chronic problems or can be used for long-term monitoring and diagnosing of transient events.

The monitors automatically display the line frequency and line voltage, test an outlet's wiring, and record the number of voltage and frequency spikes and drops, as well as the minimum and maximum values.

For More Information Circle No. 712



Nyden Corp., San Jose, CA, offers the PLG240 programmable bipolar stepping motor **driver/controller** with PLG240 Commander software. The controller features an embedded micro-controller for communication with a host PC. Motion profiles and parameters, I/O control line, and timers can be programmed and downloaded from the host PC.

User-programmable opto-isolated I/Os (three input and two output) allow interfacing with other parts of a multi-axis motion control system. Other features include auto current reduction, pluggable terminals for easy system interfacing, and an on-board LED status indicator. The unit also has an integral on-board power supply for +5V logic circuits.

For More Information Circle No. 714

The SCA-100 **controller/amplifier** from BEI Sensors and Systems, Kimco Magnetics Div., San Marcos, CA, is an intelligent control and amplifier package for closed-loop servo control. It is designed to provide position, velocity, and torque control for actuators and other devices. The unit is based on a 16-bit microprocessor architecture. Integrated with the microprocessor control is a built-in PWM amplifier, which handles drive functions.

The system has I/O capability for operations such as limits, home position sensing, emergency stop, or completion of a machine sequence signaling. Eight TTL input I/Os, eight TTL output I/Os, and three analog I/Os allow the system to interface with a variety of machine functions.

For More Information Circle No. 715

INDUSTRY LEADERS

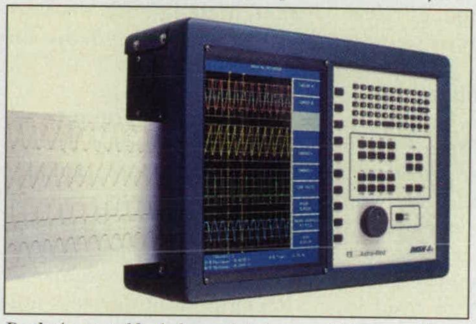
Profiles Of Pathsetting Companies Serving The Engineering Field

ASTRO-MED, INC.

Astro-Med, Inc. is a leading supplier of specialty printers and data acquisition systems to customers around the world. Astro-Med customers include leading aircraft manufacturers, automotive product manufacturers, telecommunications companies, electrical utilities, steel companies, and paper manufacturers.

Astro-Med specialty printers are total systems that display, monitor, analyze, and print data for aerospace, industrial, and scientific applications. The machines, computer electronics, software, and consumables all are developed and manufactured by the company.

Examples of Astro-Med products include the MT95K2, which has become the world standard in chart recorders, especially in telemetry applications. Other data acquisition recorders from Astro-Med include the "Dash" line of portable units, which range from 2 to 30 channels. The recently introduced Dash 4u is a 4-channel data acquisition recorder with universal inputs that features a 10.4-inch color LCD monitor, a 4-Gigabyte internal hard drive, and a 100-Megabyte removable Zip drive for data transfer and archiving.



Dash 4u portable 4-channel data acquisition recorder.

Other Astro-Med products include portable paperless data acquisition systems. The AstroDAQ is a complete, ready-to-use system that can record up to 30 channels. The AstroDAQ 2 is a very compact and lightweight version, especially suitable for portable field applications.

Astro-Med is a growth-oriented company that believes in vigorous new product development, in high-quality products, and in total customer satisfaction. Astro-Med's executive offices, R&D, and manufacturing facilities are located in West Warwick, RI and Braintree, MA.

For more information, contact Astro-Med, Inc., Astro-Med Industrial Park, West Warwick, RI 02893; Tel: 800-343-4039; Fax: 401-822-2430; e-mail: astro-med@astro-med.com; www.astro-med.com

Circle No. 753

VISIONARY DESIGN SYSTEMS, INC.

Visionary Design Systems, Inc. (VDS) is the leader in e-Engineering™ total design chain integration. Founded in 1990, VDS was a pioneer in bringing solid modeling technology into companies and helping them streamline the product development process, rapidly growing to become the fourth largest CAD/CAM system integrator in North America. VDS introduced IronCAD™ in 1998, the hottest new solid modeling system in the industry. IronCAD combines product development with the power of the Web, creating interactive integration, enabling never-before realized collaboration and productivity for everyone in the design chain.

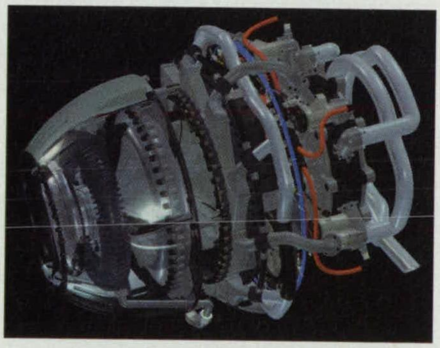
The IronCAD Difference

Drag and Drop Solid Modeling: The first true 3D design environment for solid modeling dramatically enhances productivity for casual and experienced users alike.

DesignFlow™ Architecture: The first new modeling architecture in a decade is the first and only solid modeling architecture with the power to capture design intent, but with the freedom to make unanticipated changes at any time during the design process.

Visual Product Development: The integration of high-end visualization technologies into the core of the software makes the entire design process faster, more productive, and more understandable.

Hyper-Operability: Beyond the simple import of CAD data from other systems as dumb reference art, IronCAD can actually utilize and modify imported data as though it were created natively.



For more information, contact Visionary Design Systems, Inc., 2790 Walsh Ave., Santa Clara, CA 95051; Tel: 800-339-7304; Fax: 408-969-9633; www.ironcad.com

Circle No. 755

UNIGRAPHICS SOLUTIONS

The product development market has become one of multiple users and buyers in large, medium, and small companies. While each segment requires different levels of capability, they are linked together by the requirement to team on master model design and assembly projects.

Unigraphics Solutions' (UGS) mission is to provide to this market a combination of software products, and implementation and integration services addressing the product and process complexity involved in these collaborative efforts.

Unigraphics Solutions offers scalable, integrated, enterprise-level MCAD solutions for virtual product development, principally in the automotive and transportation, aerospace, consumer products, equipment and machinery, and electronics industries.

The UGS product suite includes Unigraphics, its high-end MCAD software product for complex design, manufacture, and assembly projects, to Solid Edge, its Windows-based, easy-to-use design and drafting product. Both Unigraphics and Solid Edge are based on UGS's core solid modeling kernel, Parasolid. As a result, UGS differentiates itself from its competitors by enabling Unigraphics and Solid Edge to seamlessly share geometric data without the need for translation. Our PDM software, IMAN, is one of the industry's most functional product data management tools for engineering applications. IMAN captures, manages, and provides enterprise-wide access to the large volume of data generated throughout the virtual product development cycle.

For more information, contact Unigraphics Solutions; Tel: 800-498-5351; e-mail: uginfo@ugsolutions.com; www.ugsolutions.com

Circle No. 770

KEITHLEY INSTRUMENTS, INC.

A World of Measurement Solutions

Keithley Instruments, Inc. develops highly accurate instruments and data acquisition products that measure low levels of voltage, resistance, current, capacitance, and charge, along with complete system solutions for high-volume production and assembly testing. As a world leader for over 50 years in precision electrical measurement solutions, Keithley specializes in equipment for research, design engineering, and production test applications in a wide range of electronics industries.

Communication

Keithley offers a broad line of fully integrated products for testing portable telecommunications devices such as cellular phones, pagers, mobile radio base stations, and digital switch systems used in product design, production, and QA/QC labs.

Semiconductor

Keithley's products include instruments and systems widely used in design and development, as well as systems for parametric testing.

Electronic Components

Keithley's growing line of high-throughput solutions for component testing encompasses the entire spectrum of control, connect, and source-measure instrumentation.

Recently, Keithley test and measurement innovations have included an expanded selection of PCI-based data acquisition and digital input/output boards, high-speed power supplies optimized for testing battery-operated wireless devices, and several additions to its already broad line of switch cards.

With more than 550 employees, subsidiaries in ten countries, and sales representatives in more than 40 countries, Keithley truly offers "A World of Measurement Solutions."

For more information, contact Keithley Instruments, Inc., 28775 Aurora Road, Cleveland, OH 44139; Tel: 888-534-8453; Fax: 440-248-6168; www.keithley.com

Circle No. 771

OCEAN OPTICS, INC.

Miniature fiber optic spectrometers for the UV, VIS, and Shortwave NIR (200-1100 nm) offer high performance at a low cost, in a convenient, modular package that is attractive to R&D professionals and OEM developers.

Each standalone spectrometer is custom-built to the user's specifications. The spectrometer comes with a fixed grating, set to a user-specified wavelength range, and can be configured with optical bench accessories such as UV windows, entrance slits, detector collection lenses, and order-sorting filters.

Ocean Optics spectrometers connect to a comprehensive line of fiber optic accessories, including light sources, probes, and chemical sensors. This modular approach — in which components are easily mixed and matched — allows users to create small-footprint systems for myriad applications.

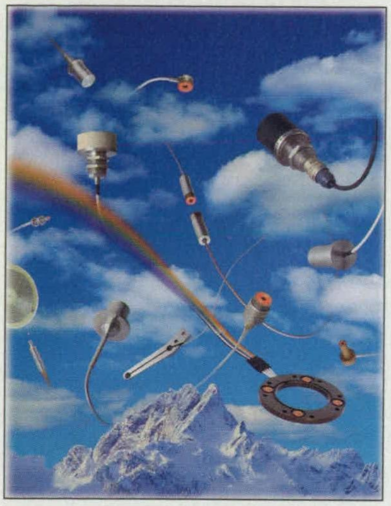
Users can configure custom systems for an almost endless variety of optical-sensing applications, or choose from among pre-configured systems for Raman analysis, spectroradiometry, fluorescence experiments, oxygen sensing, and chemistry-lab teaching. What's more, users can integrate OEM components into analytical instrumentation for applications ranging from cancer detection, to color measurement, to laser characterization, and LED analysis.

For more information, contact Ocean Optics, Inc., 380 Main Street, Dunedin, FL 34698; Tel: 727-733-2447; Fax: 727-733-3962; e-mail: info@oceanoptics.com; www.oceanoptics.com

Circle No. 754

KAMAN INSTRUMENTATION

The World's Leader in Noncontact Position Measuring Systems



Kaman Instrumentation has over 30 years of experience with noncontact position measuring techniques. Kaman's advanced family of high-precision sensors is based on inductive or eddy current technology, which makes them extremely reliable systems. They provide very stable and repeatable measurements and are unaffected by humidity, dust, and other contaminants. For use with metal targets, Kaman's noncontact sensors feature measuring ranges from 0.002 to 2.5 inches; high-speed analog and digital signal conditioning; and rugged stainless steel and PEEK housings. Kaman offers single-coil systems as well as dual-coil and matched differential pair systems that minimize temperature, radiation, and other environmental effects. Sensors operate in temperature ranges from 4°K to +1000°F (+538°C).

Kaman specializes in solving difficult measuring applications; anything from monitoring shaft alignment in a cryo compressor, to monitoring fuel rod vibration in nuclear power plants. Kaman's applications engineers are true specialists that will assist system designers and OEMs in selecting and developing a system for their particular applications, and will support them from initial contact, through installation and operation.

For more information, contact Kaman Instrumentation, 1500 Garden of the Gods Road, Colorado Springs, CO 80904; Tel: 800-522-6267; Fax: 719-599-1823; e-mail: info-cos2@kaman.com; www.kamaninstrumentation.com

Circle No. 773

STAHL SPECIALTY COMPANY

Stahl Specialty Company is a leader in the aluminum foundry industry and has been making castings from the tilt-pour permanent mold process since 1946. Automotive, agricultural, and food service are some of the markets in which a casting design can be more viable than other manufacturing processes. Stahl has been making parts for the automotive industry since 1978. One automotive area in which Stahl has expertise is suspension parts such as control arms.

The main reason for converting suspension parts to aluminum from other materials such as iron castings and steel stampings is weight savings. This translates into lower vehicle weight and better fuel economy. One important side benefit is an improvement in unsprung weight of each wheel, which refers to the amount of mass of each wheel that is available to be "thrown around" as the vehicle encounters bumps and potholes. When the wheel of a car with lightweight aluminum control arms passes over an abnormal road surface, the impact is less violent and yields a smoother ride.

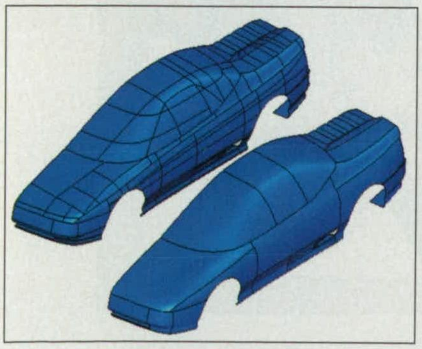
Aluminum control arms are fairly new to the automotive industry, but they become more widespread each model year. Superior mechanical properties and casting soundness are a must for the aluminum control arm to be successful. Castings with high ultimate tensile strength are required, but ductility of the casting is a prime consideration. Aluminum control arms must show signs of deformation before failure, which places a premium on the elongation percentage of the casting. To achieve the elevated mechanical properties required for control arm applications, the castings must also have minimal internal anomalies such as porosity and oxides. A sound casting, combined with a custom tailored heat treat, will yield a casting with exceptional mechanical properties and durability.

For more information, contact Stahl Specialty Co., 111 East Pacific, PO Box 6, Kingsville, MO 64061-0006; Tel: 800-821-7852; Fax: 816-597-3485; www.stahlspecialty.com

Circle No. 752

INTERNATIONAL TECHNEGROUP INC. (ITI)

CAD Geometry Healing Software



CADfix™ repairs IGES, STL, AutoCAD, Parasolid, STEP files, and more. Geometry and topology imperfections in CAD models (gaps, duplicate entities, unclosed shells, disconnected surface models, sloppy edges and faces, loose tolerances, etc.) make exchanging and working files nearly impossible at times. Geometry errors waste time and money as files are returned to the designer for repair, or even recreated entirely.

ITI's CADfix assesses files and makes corrections to geometry and topology errors — either automatically or interactively. CADfix imports/repairs/exports the following types of files: IGES, STL, STEP, Parasolid, ACIS SAT, AutoCAD, and CADDS. CADfix can also be output to ANSYS.

CADfix allows you to:

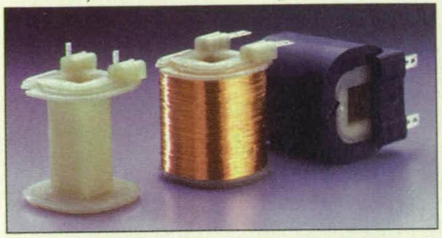
- Freely exchange 3D solid and surface models
- Effectively reuse CAD geometry in Analysis, NC, Rapid Prototyping, and Data Exchange applications
- Eliminate the need to recreate files before you can use them
- Quickly recover legacy data

For more information, contact International TechneGroup Inc., 5303 DuPont Circle, Milford, OH 45150; Tel: 800-783-9199 or 513-576-3900; e-mail: info@iti-oh.com; www.iti-oh.com/interoperability

Circle No. 775

DUPONT ENGINEERING POLYMERS

ABB (Raleigh, NC) is racking up major savings in production costs while maintaining high reliability with a new encapsulated voltage coil made with DuPont Zytel® nylon resin. Used in ABB's single-phase and polyphase electromechanical watt-hour meters, the new coil replaces an older design overmolded with thermoset epoxy. The new coil represents a milestone in the high-voltage performance of thermoplastic-encapsulated coil devices. Before installing the coil in a meter, ABB tests each one twice at 8 kV with a specific wave form simulating a powerful lightning surge.



Bobbin for voltage coil is molded from DuPont Zytel® nylon.

Russell Broome, ABB's project engineer for the voltage coil, said, "We took advantage of the toughness, strength, and high-productivity molding characteristics of Zytel nylon in designing the coil bobbin with automated winding, termination, and encapsulation in mind." The resin grade used is Zytel® 70G33HS1L, a heat-stabilized nylon 66 resin with 33 percent glass fiber reinforcement.

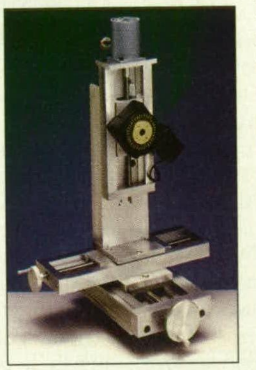
The grade of Zytel nylon used for encapsulation is the same as that of the bobbin. On the recommendation of DuPont engineers, the ABB team designed the bobbin with a groove on each flange in the area where the encapsulation material must seal to it. "Tom Boyer of DuPont provided invaluable help at every stage of the development process," said Broome. "He made recommendations involving resin grades, the design of parts and molds, and requirements for molding equipment and process controls. He also played a key role in helping us optimize process parameters for quality and productivity," Broome added. The new voltage coil is used in ABB electromechanical watt-hour meters for both residential and commercial use.

For more information, contact DuPont Engineering Polymers, PO Box 80022, Wilmington, DE 19880-0022; Tel: 800-441-0575; www.dupont.com/enggpolymers/americas

Circle No. 782

VELMEX, INC.

For three decades, Velmex manual and motorized UniSlide Assemblies have been the preferred method to produce linear and rotational motion in scientific, research, machine, instrument, and industrial applications. Hundreds of thousands of UniSlides are in use providing simple, rugged, reliable motion. UniSlide applications are limited only by your imagination. For measurement, alignment, inspection, and QA/QC, optical focusing, antenna alignment, film and animation work, medical and biological analysis, for moving probes, sensors, components, and thousands of other uses — if you need precise, versatile movement in one, two, or three dimensions, with linear or rotational motion, you can do it more efficiently and less expensively with a Velmex UniSlide.



UniSlides are available in nearly 1,000 standard manual or motorized configurations, including free-sliding models, screw drive versions, models with micrometer position readout in English or Metric calibrations, rapid advance models, in standard and high-precision accuracy. An impressive array of products. But the real versatility of UniSlides is their amazing flexibility. Because every UniSlide is built to order — customers are not limited to off-the-shelf products — you can customize your UniSlide to meet your exact requirements: rapid/fine motion, thumb screw locks, special finishes, way covers, revolution counters, position encoders, or some other feature. We can do it. UniSlides from Velmex. We've put quality into motion.

For more information, contact Velmex, Inc., 7550 State Route 5 and 20, Bloomfield, NY 14469; Tel: 800-642-6446 or 716-657-6151; Fax: 716-657-6153; e-mail: sales@velmex.com; www.velmex.com

Circle No. 768

SOLIDWORKS CORPORATION

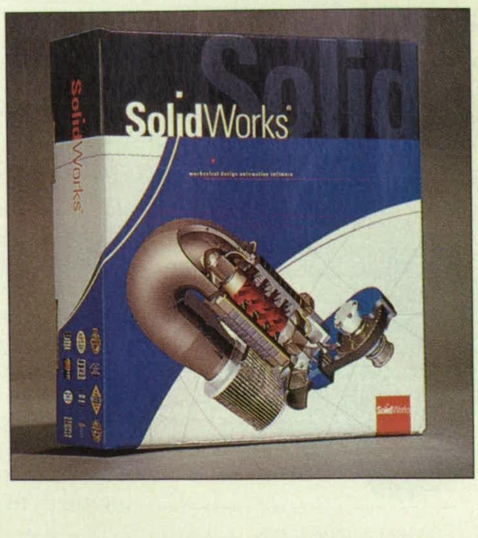
SolidWorks® 98Plus

SolidWorks is a Windows NT/95-compatible solid modeling mechanical design system. SolidWorks 98Plus includes over 200 customer driven enhancements, additions to detailing, assembly design, surfacing and sheet metal capabilities.

SolidWorks also offers its users worldwide PhotoWorks, photo-realistic rendering software; FeatureWorks, feature recognition software that allows designers to import and translate industry standard files and features; and fully integrated analysis, manufacturing, and product data management solutions from its third party partners.

For more information, contact SolidWorks Corporation, 300 Baker Avenue, Concord, MA 01742; Tel: 800-693-9000 or 978-371-5000; Fax: 978-371-5088; e-mail: info@solidworks.com; www.solidworks.com

Circle No. 777



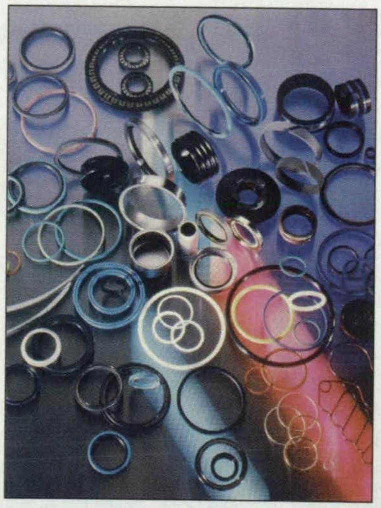
BUSAK + SHAMBAN

Global Manufacturer of High-Performance Sealing and Bearing Systems

When engineers and designers walk the National Design Engineering Show this year, they will be looking for solutions. And Busak + Shamban will have many possibilities from a variety of industries on display in Booth 431. Our proprietary seals, bearings, and materials are well known and respected by aerospace and industrial customers. Busak + Shamban sealing and bearing systems provide optimum performance, which is critical for effective hydraulic and pneumatic service, even in the toughest operating conditions.

Among the sealing and bearing products to be featured at NDES '99: Turcon® Glyd Ring® T, a double-acting O-ring energized piston seal; Turcon® Glyd Ring® II, a unitized seal; Turcon® Varilip® rotary shaft seals; Wills Rings® O and C metal face seals; Turcon® Variseal™ spring energized seals; Luytex® Slydring® wear rings; and HiMod® and Durobal® thermoplastic bearings.

Busak + Shamban is ISO certified and supports all methods of customer audits, statistical



process control, material resource planning, and advanced quality systems. With three R&D centers, 11 manufacturing plants, and 33 sales offices, all strategically located worldwide, Busak + Shamban offers custom engineering, resin compounding, design assistance, manufacturing excellence, and expert customer service.

For more information, contact Busak + Shamban; Tel: 800-466-1727; Fax: 303-469-4874; www.busakshamban.com

Circle No. 795

SYNRAD, INC.

Laser Technology for Industry

Since its start in 1984, Synrad, Inc. has come to be recognized as a leader in the development of sealed CO_2 lasers and electro-optic technologies. Founded by Peter Laakmann, who pioneered the RF-excited CO_2 laser, Synrad has delivered more CO_2 lasers to industry than any other manufacturer. Currently, Synrad lasers cut, mark, drill, and perforate a multitude of materials in over 20,000 installations worldwide. In August 1998, Synrad was acquired by Excel Technology. Excel and its subsidiaries develop, manufacture, and market laser systems and electro-optical components for electronic, semiconductor, other industrial, scientific and medical applications.

Synrad's expansive product line includes sealed CO_2 from 10 to 600 watts, the patented Power Wizard™ hand held laser power meters, laser marking systems and WinMark Pro™ laser marking software.

Synrad's latest product is the Fenix™ laser marker. This compact, self-contained laser marking system delivers crisp, accurate marks in even the toughest environments, and Fenix is priced at $15,900 — about ⅓ less than comparable laser marking systems. Fenix operates from Synrad's own Windows-based laser marking software, WinMark Lite or WinMark Pro. The ease of use and flexibility of this software make Fenix ideal for marking alphanumerics, bar codes, and logos.

For more information, contact Synrad, Inc., 6500 Harbour Heights Pkwy., Mukilteo, WA 98275; Tel: 800-SYNRAD-1; e-mail: synrad@synrad.com; www.synrad.com

Circle No. 783

SIFCO SELECTIVE PLATING

Take Control of Your Production Plating Needs With Automated Selective Plating

The SIFCO Process® of selective plating that you've been using since 1959 to repair worn, damaged, or mismachined components is easily adaptable to automate for selectively applying electroplated deposits or anodized coatings onto your production parts.

SIFCO Selective Plating proudly introduces ASP (Automated Selective Plating), which uses custom-designed systems to selectively apply a full range of deposits that include the same high-quality nickel we've plated on over 300 areas of various Space Station components.

ASP systems are designed to allow high-volume plating of select areas on parts ranging in size from the head of a pin, to as large as an automotive crankshaft. ASP provides:

- Real-time process monitoring to reduce scrap, rework, and downtime.
- A self-contained system that improves environmental compliance and minimizes safety concerns.
- A nest design that allows change-over to different components for production flexibility.
- A compact design that uses less than 200 square feet.

At plating rates 30 to 60 times faster than conventional tank plating, the system provides high quality, adherent, defect-free deposits when and where you need them.

For more information, contact SIFCO Selective Plating, 5708 Schaaf Road, Cleveland, OH 44131; Tel: 216-524-0099; Fax: 216-524-6331; e-mail: info@brushplating.com

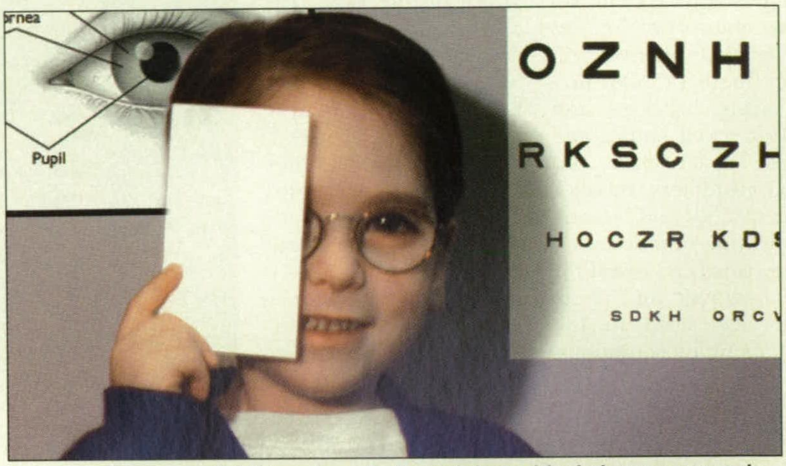
Circle No. 751

ALGOR®

Eye Development During Childhood Studied With Mechanical Event Simulation

As you read these words, you are experiencing the miracle of sight made possible by both the geometric shape of your eyes and the correct arrangement of cells.

Neuroscientist Alan Springer, Ph.D., at the New York Medical College in Valhalla, New York is studying how the shape of eye tissue and arrangement of light-sensing cells develop. Using Mechanical Event Simulation (MES) software from Pittsburgh-based ALGOR, Inc. Dr. Springer has created a virtual biomechanical model of the central region of the eye's retina to support his hypothesis that eye growth and the stretching of tissue causes cells to passively assume the shape and distribution necessary for good vision. A greater understanding of retinal development could lead to advances in the treatment of eye disorders.



Eye examinations of children have indicated that critical changes occur in eyesight over the first eight years of life. Using Mechanical Event Simulation software from Pittsburgh-based Algor, Inc., Dr. Alan Springer at the New York Medical College in Valhalla, New York created a virtual biomechanical model of retinal development. He believes that a greater understanding of early eye development could lead to advances in the treatment of eye diseases and abnormalities.

Observing Eye Development

As light enters your eye, a lens directs the light onto the retina, the interior back surface of the eye. The fovea, a small region in the center of the retina, contains a higher density of light-sensing photoreceptors than the surrounding retina, thus providing high visual acuity. Dr. Springer simulated human foveal development using MES to research how photoreceptors become concentrated in the fovea when a newborn's retina contains an even layer of photoreceptors.

The retina consists of an outer layer of photoreceptors and an inner layer consisting of nerve cells (ganglion and inner nuclear cells). The photoreceptor layer is initially one cell thick. Beginning in an unborn child's third trimester, the inner retinal layer, in the area that will become the fovea, is thicker than the surrounding retina. At about five to eight years of age, retinal cells in the inner layer move centrifugally away from the center of the fovea, resulting in a cone-shaped pit. The pit starts as a mere shallow notch and then grows larger over time. This movement removes cells that presumably obstruct light from impinging on the underlying photoreceptors. At the same time, photoreceptors move centripetally toward the center of the fovea, resulting in more photoreceptors arranged in a multilayered mass at the center of the fovea.

Scientists disagree on how and why changes in the retina occur. Possible explanations relate to genetics, biochemistry or the active movement of cells during eye development. Dr. Springer theorizes that the foveal region forms because of active eye growth and the ensuing passive stretching of the retina.

Modeling Eye Tissue

Because eye growth takes place over the course of about eight years, eye growth research is not amenable to experiments with real tissues. ALGOR's MES software enabled Dr. Springer to study the biomechanics of eye growth in a short period of time.

Dr. Springer was concerned with how the shape of the fovea changes over time (displacement). The displaced shapes created by MES could be compared to the changes in shape observed in human eyes at various stages of development. Dr. Springer found that nonlinear and Mooney-Rivlin material models could supply meaningful results about foveal changes. He used published values for the collective material properties of eye tissues.

Dr. Springer used four models to examine the development of the foveal pit from a notch. The first and second models were 2-D representations of the inner retinal layers with a small notch. For the first model, Dr. Springer fixed one end and displaced it in the X direction using a tangential force to simulate stretching. Dr. Springer fixed the second 2-D model, a curved representation of the inner retinal layers, at both ends and applied pressure to the inner surface to cause displacement.

For both models, as the notch grew larger over time, the outer edge of the retina beneath the foveal pit deflected upward, suggesting that as the retina stretches, the notch in the inner retinal layer undergoes tension directed toward its inner surface. Tensile stresses could be transmitted to the underlying photoreceptor layer, thereby drawing the photoreceptors to the area underlying the base of the notch. Material overlying the notch was displaced less than material more distant from the notch.

Dr. Springer's third model showed the behavior of a 3-D elastic hemisphere with a notch in its inner surface. Boundary conditions fixed the base of the hemisphere and pressure was applied to the model's inner surface causing displacement. As pressure increased, the hemisphere became thinner, the notch in the inner surface widened and the outer surface of the hemisphere overlying the notch deflected toward the inner surface of the hemisphere (Figure A below).

The first three models suggest that as a developing retina is stretched by growth, the foveal notch in the inner layer of the retina may act to deflect the cells away from the outer surface of the retina. Such movement could serve to draw cone photoreceptors toward the center of the fovea. To examine the interaction between the inner retinal and photoreceptor layers, Dr. Springer added a model representing the photoreceptor layer to his first model using beam elements as connectors.

For this fourth model, Dr. Springer fixed the nodes on one end and applied a force to the other end. To simulate the contour found in a normal retina, Dr. Springer constrained the nodes on the outer surface of the photoreceptor layer. They were constrained in the X, but not the Y, plane. After the combined model was stretched, the notched area of the inner retinal layer deflected upward and, via the beams, pulled the outer layer of photoreceptor cells centripetally toward the center of the notch (Figure B below).

Extending this result to the retina, eye growth-induced retinal stretch would result in the passive centrifugal movement of the inner retinal layer cells away from the center of the fovea and the centripetal movement of photoreceptors toward the center of the fovea. Stretching of the inner layer of the retina may generate the force that induces the centripetal viscoelastic flow of the underlying cone cells.

Continuing Eye Growth Research

Dr. Springer's research to date shows that the development of the fovea from a notch to a pit is biomechanical in nature. In the future, he plans to work with virtual models to evaluate a biomechanical hypothesis of foveal pit formation. Additionally, Dr. Springer is initiating clinical research into noninvasive treatment for strabismus, a disorder that may be caused by uneven rates of eye growth. Currently, surgery is the only treatment for strabismus.

A better understanding of eye development may lead to better treatment of poor vision due to improper eye growth and retinal or other eye diseases.

Note: For a more detailed version of this story, visit the Customer Application Stories section of ALGOR's web site: www.algor.com.

ALGOR has been a leader in the engineering software industry since it introduced FEA for PCs in 1984 and interfacing with CAD systems in 1985. For 20 years, ALGOR has provided finite element users with innovative, affordable and easy-to-use software products and superior educational support and customer service.

More than 16,000 scientists and engineers in 60 countries use ALGOR to create safe, efficient, cost-effective designs. Scientists have researched the biomechanics of conditions, such as scoliosis, and developed medical devices such as biopsy needles and dental implants. Engineers use ALGOR in the aerospace, automotive, medical and consumer products industries.

ALGOR offers advanced modeling, CAD interfacing and FEA tools. ALGOR's Accupak/VE combines stress analysis with motion for physics-based Mechanical Event Simulation and Virtual Prototyping. ALGOR's other FEA capabilities include linear and nonlinear stress, vibration and natural frequencies, heat transfer, electrostatics, fluid flow, piping design and composite materials.

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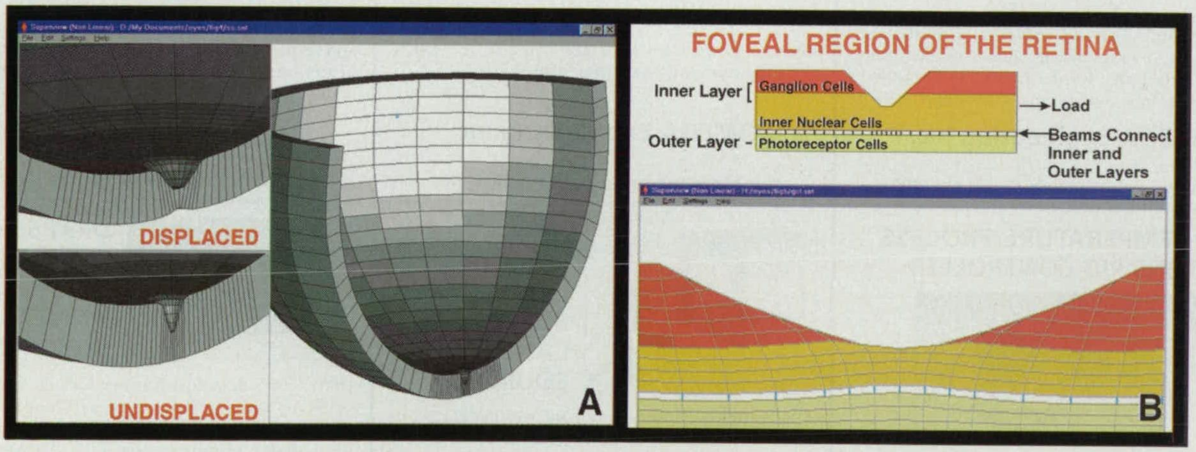
For more information Circle No. 776



A. Dr. Springer applied pressure to a 3-D hemisphere (here shown sliced in half). Insets show the initial shape of the fovea and its deflected shape. B. The combined model of the inner layer of the retina and the outer photoreceptor layer showed that the notched area of the inner retinal layer deflected upward and pulled the photoreceptor material centripetally toward the center of the notch. These results support Dr. Springer's theory that the foveal region forms because of active eye growth and the ensuing passive stretching of the retina.

DESIGN ENGINEERING PRODUCT SHOWCASE

New Products and Services for NASA Tech Briefs readers. For more information, write in the corresponding number on the Free Information Request Card (following page 40).

1/32 DIN TEMPERATURE/PROCESS PANEL METER

Standard features of the DP1632 Series include universal inputs that accept thermocouple, RTDvoltage, or current inputs. The large display is available in red or green. The meter is °C/°F programmable.

OMEGA Engineering Inc.
For More Information Circle No. 600

1/4, 1/8, AND 1/16 DIN TEMPERATURE AND PROCESS CONTROLLERS

The CN2200 Series features include: PID or On/off control; heating and cooling; autotune with overshoot inhibition; setpoint rate limit; universal temperature and process input; two modular control outputs configurable as reverse/direct action or alarm; load diagnostics with optional SSC-TE10S contactor; multiple alarms configured on a single output; two-wire RS-485 communications; 10 amp heating output (CN2204 only); up to three alarm relays; two digital inputs for second setpoint or auto/manual select; isolated analog control output module.

OMEGA Engineering Inc.
For More Information Circle No. 601

BLACKBODY CALIBRATION SOURCE WITH LARGE 4-INCH CAVITY OPENING

The BB704 temperature reference source calibrates from 100 to 398 °C (212 to 752 °F). It also calibrates infrared pyrometers quickly and accurately. Features include portable rugged design; large 101.6mm (4-inch) aperture; built-in digital PID autotune temperature controller with temperature readout; NIST traceable calibration certificate with three temperature DATA points included; RS-232 output standard; built-in reference probe standard.

OMEGA Engineering Inc.
For More Information Circle No. 602

MICROPROCESSOR-BASED THERMOCOUPLE/PROCESS 1/8 DIN DIGITAL INDICATOR

The DP1610-R1 Series features include: four-digit red or green LED display; universal sensor input: T/C, 3-wire RTD, DC voltage, or current; latching or non-latching relay; max/min hold and time elapse; universal power supply; IP65/NEMA 4 front panel; engineering unit labels supplied for faceplate. Optional features include: second and third alarm relays; remote reset for alarms; analog output; transmitter power supply ; RS-485 communications; low-voltage power; fully configurable with laptop or PC.

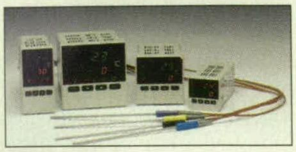
OMEGA Engineering Inc.
For More Information Circle No. 603

STICK-TYPE PORTABLE METERS

The OS641/OS642 stick-type infrared pyrometers feature: stick-type meter and transducer; portability and simple one-hand operation; auto-hold function after releasing MEAS button; laser sight on selected models, with fixed emissivity (E) 0.95 for most substances; transducer with retractable cable that expands to 1m and terminates with banana plug; auto power-off function. Battery: 4 pcs 1.5 V (AAA size). Dimension: 170 H x 44 W x 40mm D (7 x 2 x 1.5"). Weight: 200 g (7 oz.). Valox housing withstands accidental drops.

OMEGA Engineering Inc.
For More Information Circle No. 604

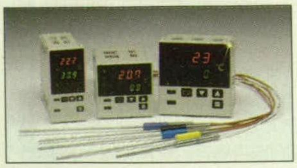
CN140 TEMPERATURE/PROCESS AUTOTUNE PID CONTROLLERS



The CN140 series includes thermocouple, RTD, and mV inputs available in one unit (voltage and current input models are available); On/off and PID control with autotune; dual display — process and setpoint; optional absolute or deviation alarms, heater break, and setpoint (SV) bias; programming made easy from the front panel.

OMEGA Engineering Inc.
For More Information Circle No. 605

CN130 TEMPERATURE/PROCESS AUTOTUNE PID CONTROLLER



The CN130 Series offers these standard features: 68mm square, 1/4 DIN, and 1/8 DIN vertical sizes; 12 types of thermocouples, RTD, voltage, and current-input models; isolation of inputs and outputs; automatic or manual tuning on demand.

OMEGA Engineering Inc.
For More Information Circle No. 606

HIGH-TEMPERATURE LABORATORY BLACKBODY CALIBRATION SOURCE

Model BB705 calibrates from 100 to 1200°C (212 to 2190°F) and calibrates infrared pyrometers quickly and accurately. Features include built-in NIST traceable reference temperature display; large 44.5mm (1.75") aperture; built-in PID autotune control with digital readout; RS-232 output standard. NIST Traceable Calibration Certificate is included.

OMEGA Engineering Inc.
For More Information Circle No. 607

DP31 SERIES 1/8 DIN DUAL INPUT UNIVERSAL INDICATORS

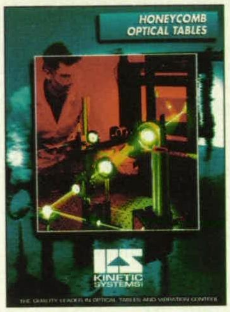
DP31 Series Standard features include: dual inputs (differential or temperature and humidity); two-character display for engineering units; self-calibration; analog retransmission; 0.1% accuracy; transmitter power supply; five-digit display (range: 10,000 to 20,000); programmable to scan between temperature/relative humidity; min/max average and totalization measurement functions; four-alarm indication; one-alarm output relay; universal power supply (85 to 264 Vac); plug on connections; only 4.53" deep; NEMA 4 front-panel protection.

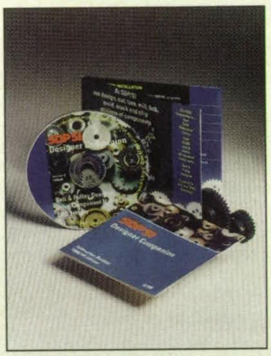
OMEGA Engineering Inc.
For More Information Circle No. 608

New LITERATURE

Optical Tables

Kinetic Systems, Boston, MA, has published a 24-page brochure detailing optical tables and accessories. Included are technical considerations for the selection process; product information for more than 3,500 standard table options; and detailed descriptions of breadboards and support systems. **Circle No. 733**

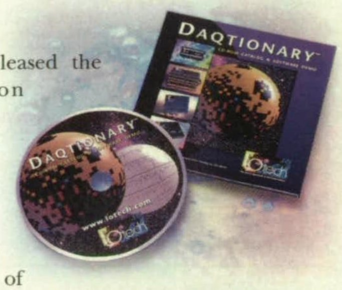




Downloadable CAD Drawings

The Designer Companion D700 is a CD-ROM from Stock Drive Products/Sterling Instruments, New Hyde Park, NY, that includes CAD drawings for more than 45,600 components. Drawings are in both DWG and DXF formats. Drawing types include gears, belt and chain drives, shafts and accessories, bearings, couplings, gearheads, breaks and clutches, and motors. **Circle No. 734**

Data Acquisition CD



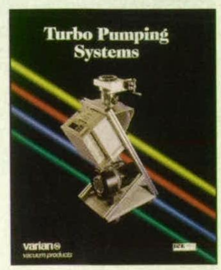
IOtech, Cleveland, OH, has released the DAQtionary™ Data Acquisition Catalog and Software Demo CD. Features include portable PC-based data acquisition systems; signal-conditioning and expansion options; temperature-and-voltage scanners; IEEE 488 interfaces; and the Personal Daq™ family of USB-based systems. A Software Selection Guide offers tutorial-based demonstrations of IOtech's enhanced Out-of-the-Box™ software, datalogging and control software, and third-party software support. **Circle No. 735**

Signal Conditioning

A new 230-page catalog from Analog Devices, Norwood, MA, covers the industry-standard 3B, 5B, 6B, and 7B Series signal-conditioning modules. The catalog, also available on CD-ROM, offers ordering information on module configurations, computer cabling and interconnections, backplane, power supplies, and accessories. **Circle No. 736**

Turbo Pumping Systems

Varian Associates, Palo Alto, CA, offers a Turbo Pumping Systems Catalog outlining high-vacuum systems, which can be custom-configured. Products include four standard turbo-pumping system platforms designed to provide a range of speeds from 40 to 900 liters per second. Also offered are gauge controllers and transducers, valves, vacuum hardware, and accessories. **Circle No. 737**



Control Boards

ComputerBoards, Middleboro, MA, has released a 144-page guide that provides data sheets for PCI- and CPCI-based data acquisition and control boards, software information, and abbreviated information on all products. The company also offers a line of GPIB/IEEE-488.2 and serial-communications interface products. **Circle No. 738**

Controls and Indicators

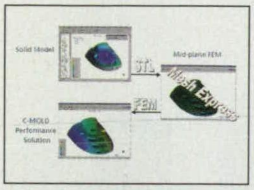
Love Controls, Michigan City, IN, offers a catalog with separate sections for controls, indicators, sensors, transmitters and alarms, and data communications and recorders. Each section includes photographs, charts, diagrams, specifications, product descriptions, and ordering information. **Circle No. 739**

New on DISK

Image Processing

ENVI® Version 3.1 from Research Systems, Boulder, CO, is an image-processing application for analyzing remote-sensing data. ENVI (Environment for Visual Images) includes traditional image-processing features along with advanced radar and hyperspectral analysis tools. It offers new vector and GIS tools, including the ability to import ArcView shape files, and vector creation, editing, and query capabilities. 3D SurfaceView allows users to drape an image over a digital elevation model (DEM) and use joystick-like mouse controls to change views and positions and set up fly-throughs of images. **Circle No. 724**

FEA Models From CAD

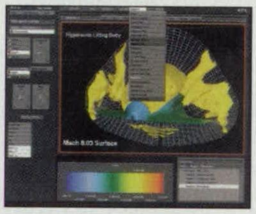


C-MOLD, Louisville, KY, has announced C-MOLD® Mesh Express software, which converts CAD geometry into mid-plane finite element models (FEM) using a stereolithography (STL) file format. Models converted using Mesh Express can be used with all C-MOLD Advanced simulation modules, including Shrinkage and Warpage. **Circle No. 725**

Nonlinear Material Model

Algor, Inc., Pittsburgh, PA, has introduced a general von Mises nonlinear material model that provides an enhanced stress-strain curve that better represents the physical behavior of many materials beyond the yield point. The general von Mises model is used in nonlinear analysis for materials subjected to large strain and that follow a stress-strain curve, such as metals and alloys. It can be applied to materials with kinematic and isotropic strain hardening for reversing or cyclic loading processes. The general von Mises model is included with Algor's Windows-based Release 12 software for PC workstations. **Circle No. 727**

Data Visualization

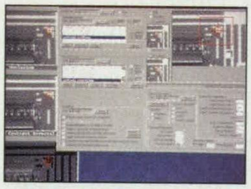


AVS5® from Advanced Visual Systems, Waltham, MA, is a UNIX™-based suite of data visualization and analysis techniques that incorporates traditional visualization tools — such as 2D plots and graphs and image processing — with 3D interactive rendering and volume visualization. AVS5 enables users to analyze, manipulate, and display large volumes of complex data, including 2D and 3D images, 3D graphics, and multi-dimensional numeric data. It is compatible with UNIX workstations from Hewlett-Packard, Sun Microsystems, IBM, Silicon Graphics, and Digital Equipment Corporation. Applications include medical imaging, energy exploration, and scientific research. **Circle No. 728**

Cross-Sectional Scanning

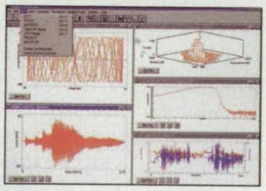
CGI®, Minneapolis, MN, has announced Spec.Check™ inspection software, which measures points, lines, arcs, circles, and roundness analyses through proprietary algorithms. Features include three different methods of part registration: manual, best-fit, and feature-based. The software creates a dimensional template for the first part, which is used to automatically dimension subsequent parts. Each 2D cross-sectional measurement is put into standard Statistical Process Control (SPC) or Production Part Approval Process (PPAP) format. **Circle No. 729**

Search Technology



SmART Search™ from Imaging Technology, Bedford, MA, uses techniques based on artificial intelligence to locate the position of objects in machine-vision applications. SmART (Smart Alignment and Registration Tool) is designed to provide accurate search and registration results in manufacturing applications such as robotic wafer handling, wire bonding and inspection, IC assembly, and component pick-and-place. SmART Search technology allows the user to quickly locate objects or fiducial patterns in an image. A key SmART Search feature is the ability to locate objects in a wide range of real-world process variations. **Circle No. 730**

Universal Data Viewer



SoMAt Corp., Champaign, IL, offers DataXplorer, a universal data viewer designed for test and design engineers who must visualize product-test data gathered and analyzed in a variety of lab and field-test situations. The viewer presents plots, tables, and charts for quick visualization. DataXplorer embeds a software technology that allows file and data conversions to be done from any source or any number of channels. In addition to reading data, it offers options such as sequential plots, bar charts, 3D histograms, X-Y plots, and tables. **Circle No. 731**

New on the MARKET

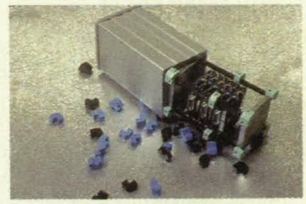
Pattern-Matching Sensor

Omron Electronics, Schaumburg, IL, offers the F10 gray-scale machine-vision sensor, designed to match patterns or detect plain objects and backgrounds. Users "teach" the F10 to recognize a pattern by focusing a visible light guide on the object. After pressing the teach button to register the pattern in the sensor, the user runs a sample test and adjusts threshold levels as needed. The F10 is then ready to run. Applications include label placement, printing verification, and conformity checks. **Circle No. 700**

Single-Board Computer

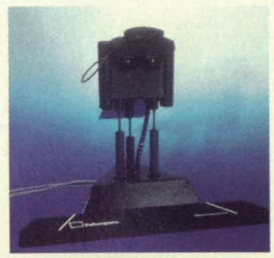
The PCM-585-133 from WinSystems, Arlington, TX, is a small AT-compatible single-board computer designed for instrumentation, portable, and mobile-systems designs. It is based on Advanced Micro Devices' 586 microprocessor, operating at a system clock of 133 MHz. The 586 CPU includes a 16KB cache and floating-point processor for math-intensive operations. The board is populated with 4MB to 32MB of surface-mounted EDO DRAM. Other features include two independent serial channels, LPT interface, floppy disk controller, IDE hard-disk interface, activity LED, and watchdog timer. **Circle No. 701**

Vibration Isolators



Shock Rocks from parvus Corp., Salt Lake City, UT, are designed to isolate and absorb shock and vibration energy in mobile, airborne, shipboard, space, and other PC/104 embedded-computing applications. They are available in either silicon or Sorbothane® material, of either 50 or 70 durometer. They attach to the outside perimeter of parvus PC/104 railed card cages, isolating all points of contact between the card cage and its extruded enclosure. Shock Rocks are designed to reduce effective G-loads in three dimensions by up to a factor of ten, depending on the application. **Circle No. 702**

Immersive Visualization



Fakespace, Mountain View, CA, has released a new model of its PUSH™ Desktop Display, designed for immersive visualization of computer-generated simulations and 3D models. The display is used on a tabletop or desk, much like a binocular microscope. Handles are used to navigate with six degrees of freedom through virtual space. Buttons on the handles provide vertical motion and can be programmed for additional interactive control. Optomechanical sensors in the desktop base and viewer module track movements, synchronizing them with application software. Features include VGA-quality (640 X 480 pixels per eye) stereo optics. **Circle No. 703**

Gyro-Based Sensor System

Crossbow Technology, San Jose, CA, offers the DMU-FOG, a fiber-optic gyro (FOG)-based sensor subsystem that utilizes silicon micromachined (MEMS) technology and proprietary digital signal processor (DSP) algorithms. Features include three fiber-optic rate sensors, a three-axis accelerometer, a temperature sensor, a 160-bit analog-to-digital converter, and a high-performance DSP and EEPROM. The 50-ounce aluminum housing measures 5 x 5 x 4". Applications include satellite communication, machine control, industrial robotics, and autonomous vehicles. **Circle No. 704**

Glass-Ceramic Connectors

A line of glass-ceramic circular connectors from Ceramaseal, New Lebanon, NY, is designed for extreme environments. These connector systems include hermetically sealed glass-ceramic headers with up to 41 gold-plated pins and a standard plug on the air side. Three design options are available on the vacuum side: double-ended with a threaded-plug connection; straight-pin design with 0.040"-diameter pins for connections; and a solder-pin design with solder-cup terminations. Connectors have 304 stainless-steel shells and are rated for temperature ranges of -269°C to 400°C. **Circle No. 705**

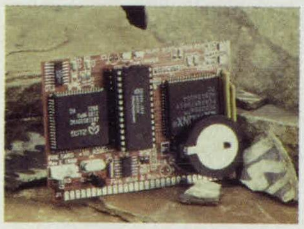
Near-Infrared Analyzer

The LabSpec® Pro spectrophotometer from Analytical Spectral Devices, Boulder, CO, is a portable, near-infrared analyzer designed for quality control in chemical, pharmaceutical, petrochemical, and food-processing industries. The unit weighs 15 pounds and operates on AC/DC or a NiMH battery. Its wavelength ranges from 350 nm to 2500 nm and penetrates a variety of plastic and glass materials, allowing testing of samples in their original containers. Probes and sampling accessories are available for fiber-optic input in measuring liquids, powders, and slurries. **Circle No. 707**

Ruggedized Notebook

Rocky II from Amrel Systems, Arcadia, CA, is a ruggedized notebook computer designed for field data acquisition (FDA) applications within vehicles. The unit can also be removed for use in field work. Features include an aluminum alloy case, sunlight-readable screen, built-in wireless modem/LAN, swappable key components, and a pen-based touchscreen. Rocky II is MIL-STD-810C/E rated for shock, vibration, water resistance, and extreme temperatures. A Backlite keyboard facilitates nighttime use. **Circle No. 708**

Single-Board Data Acquisition



Fire, Wind & Rain Technologies, Flagstaff, AZ, has introduced the Firecard 20/24 data acquisition system that includes control and removable storage on one board. Designed for use in power systems, battery chargers, and other mobile applications, the board features a 12-bit A/D converter with eight channels, two resistive 8-bit ladder D/A converters, 10 digital I/O lines, and a Z-180 24.5-MHz processor. Two serial ports with RS-232 drivers, 32 bytes of RAM with battery backup, and the FIREDOS 8-bit flash memory operating system are included. **Circle No. 747**

Digital Multimeter

The HD115B heavy-duty meter from Wavetek Corp., San Diego, CA, features an oversized character display, capacitance measuring, max/min reading hold, AC peak hold, and the company's Digi-Glo™ backlight. A Safety Tester™ feature checks for live circuits and indicates the presence of common power supply voltages with a series of LEDs. Other features include high voltage alerts, 30-minute auto-off to preserve battery life, anti-skid rubber holster, and a tilt stand. It resists damage from water, dust, chemicals, shock, and voltage transients and spikes. **Circle No. 748**

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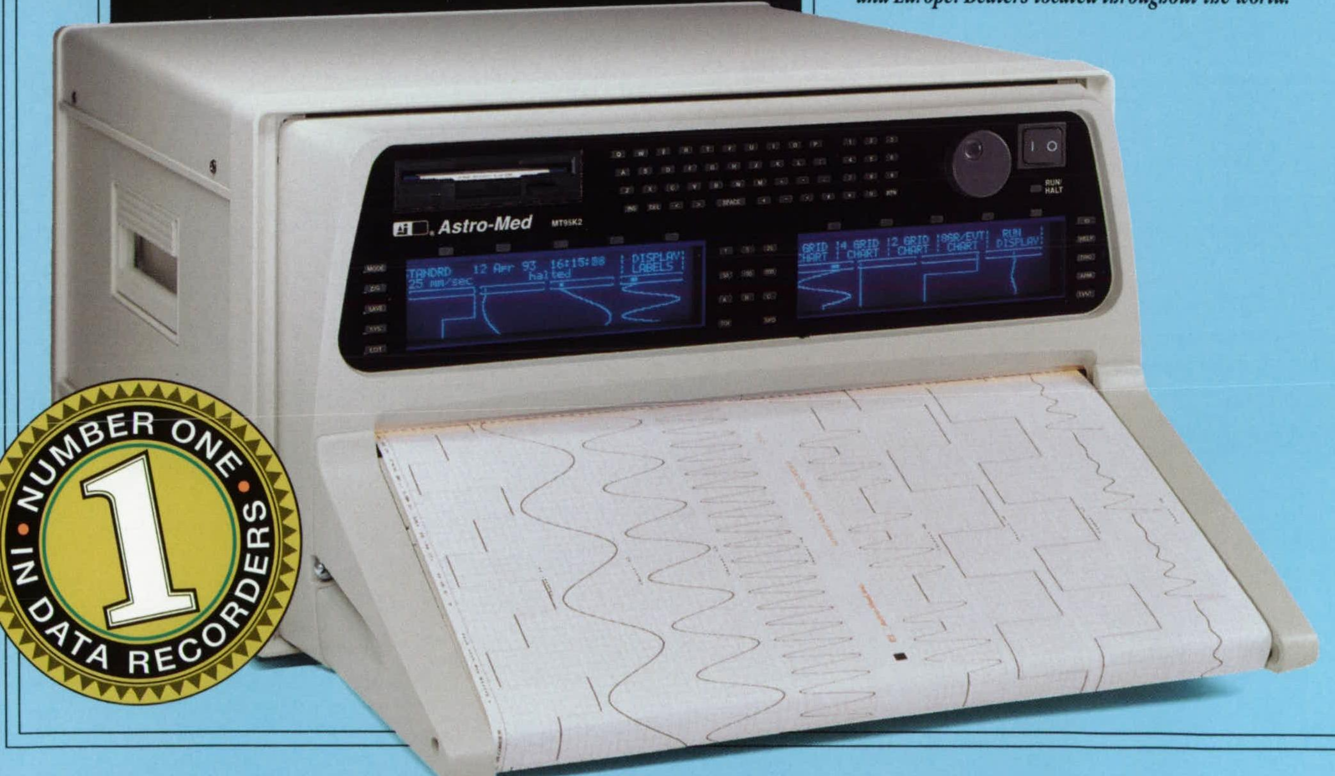

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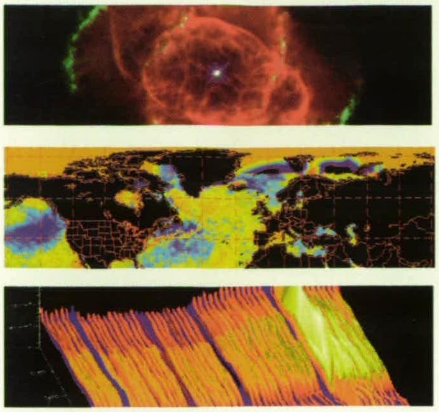

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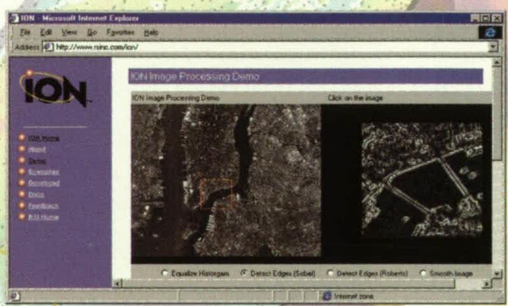

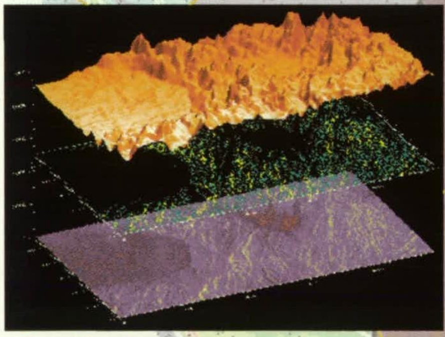

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